# TARDEC

*--- TECHNICAL REPORT ---*

THE NATION'S LABORATORY FOR ADVANCED AUTOMOTIVE TECHNOLOGY

No. 14355

WINNER OF THE 1995 PRESIDENTIAL AWARD FOR QUALITY

## M109A6 PALADIN SELF PROPELLED HOWITZER

## FULL LOAD, HIGH AMBIENT COOLING TEST AND FOLLOW ON ENGINEERING TESTS

December, 2004

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Full load, high ambient cooling tests were conducted on a M109A6 Paladin vehicle in three different configurations. The intent was to verify cooling capability of the vehicle. The powertrain configurations tested included 1) the baseline, a 440 horsepowr Detroit Diesel engine with the Allison TC360 torque converter, 2) the baseline Detroit Diesel engine with an Allison TC396 torque converter, and 3) an uppowered 500 horsepower Detroit Diesel engine and the Allison TC396 torque converter. The vehicle did not meet its specified cooling requirements, however it came close in configuration 3.

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# 1.0 INTRODUCTION

This Final Technical Report is submitted by U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) and describes the performance evaluation and analysis of results as tested in the Full-Load High-Ambient Cooling Tests (FLHACT) for the M109A6 Paladin Self Propelled Howitzer (SPH). This testing was sponsored by the Paladin Program Manager's (PM) office and performed by the Systems Integration Team using the test chamber and dynamometer facilities of TARDEC's Propulsion Laboratory.

An up-powered engine manufactured by Detroit Diesel Corporation (DDC) and a modified torque converter produced by Allison Transmission Division (ATD) have been designed and are being contemplated for inclusion in the M109A6 Paladin SPH. Through internal improvements, the DDC engine produces 60 more horsepower (for a total of 500 HP) than the baseline model. This increased power output of the engine results in more heat being generated during operation. The modified torque converter is designed to be more efficient and aid in heat dissipation. Component testing on the up-powered engine was performed at DDC facilities in Detroit, Michigan.

TARDEC performed a series of FLHACTs on three different vehicle configurations. The configurations are as follows:

| Configuration | Engine | Torque Converter |
|---|---|---|
| (Baseline) I | 440 BHP | TC-360 |
| II | 440 BHP | TC-396 |
| III | 500 BHP | TC-396 |

The goal was to perform a systems level evaluation of the proposed improvements to determine if the revised vehicle configuration will meet the cooling performance requirement. The cooling performance was evaluated in 115°F ambient temperature. The coolant used was water with 3% rust inhibitor. The FLHACTs were run at Tractive Effort to Weight (TE/WT) ratios of 0.31 through 0.37 to determine the highest TE/WT ratio the vehicle could achieve without exceeding the critical temperature limits.

In addition to the FLHACT conducted on the Paladin vehicle, the following engineering tests were also performed: Fuel Consumption, Top Speed, Engine Product Qualification (EPQ), Full-Load Cooling Tests (FLCT) at lower ambient temperatures and Full-Load/Part-Load Sprocket Power tests.

The vehicle, SN# 0009, arrived at TARDEC in May 2003 with just under 1300 miles. The vehicle was set up and instrumented in test cell 9, building 212. The testing began in October 2003 and the last test was completed 3 May 04.

## 2.0 OBJECTIVES

2.1 Conduct Full Load High Ambient Cooling Tests on the M109A6 Paladin vehicle in accordance with the Paladin Test Plan (Appendix A) to determine compliance with the cooling performance requirements in MIL-H-71000A, Section 3.15.2 stated below.

3.15.2 Cooling System. The engine water temperature, engine lubricant and transmission lubricant temperatures shall not exceed those shown in Table III when the vehicle is operated under any one or a combination of the following conditions:

a. Ambient air temperature up to 115°F.

b. At 0.35 tractive effort/weight ratio.

TABLE III. Maximum operating temperatures.

| Maximum Water Temperature From Engine | Maximum Engine Oil Temperature in Sump | Maximum Transmission Oil Temperature Into Cooler |
|---|---|---|
| 230°F | 275 °F | 300 °F |

2.2 Perform fuel consumption using JP-8 and DF-2 to determine compliance with the performance specifications stated in MIL-H-71000A, Section 3.15.4.

2.3 Perform top speed tests using JP-8 and DF-2 to determine compliance with the performance specifications stated in MIL-H-71000A, Section 3.15.5.1.

2.4 Run Engine Product Qualification (EPQ) tests including system fill, drawdown and deaeration, to determine compliance with Detroit Diesel Specification. This testing was run by TARDEC, the data was recorded by DDC engineering personnel.

2.5 Conduct Paladin Full Load Cooling Tests in all configurations, in ambient temperatures of 95°F, 100°F and 105°F and at tractive effort to weight ratios of 0.3 to 0.6 in increments of 0.05 for application of DOE to determine the main effects of the 500 hp engine on the top tank temperature. This testing was run for the Short Term Analysis Service (STAS) Program, Contract No. DAAD19-02-D-0001.

2.6 Run Full Load and Part Load Sprocket Power Tests to validate the tractive effort to weight model.

2.7 Run FLCTs with a coolant mixing device installed at the inlet to the radiator to determine mixing capability and effects on the cooling system.

## 3.0 RESULTS

3.1 Configuration I and II did not complete the FLHACT at 0.35 TE/WT in 115°F ambient air temperature. The test was stopped when the water coming from the engine exceeded the 230°F temperature limit before stabilization occurred. Configuration III exceeded the 275°F engine oil sump temperature limit at 0.35 and 0.37 TE/WT ratios during stabilized test runs in 115°F ambient air temperature. The critical temperatures from the FLHACTs are shown below.

| Configuration | TE/WT | Water from Eng °F | Engine Oil Sump °F | Trans Oil to Cooler °F |
|---|---|---|---|---|
| I | 0.33 | 221.9 | 261 | 236 |
| II | 0.34 | 220.3 | 260 | 234 |
| III | 0.35 | 229.6 | 285 | 245 |
| III | 0.37 | 227.2 | 280 | 239 |
| *Requirements* | *0.35* | *230.0* | *275* | *300* |

3.2 The Rated Power Top Speed Test results displayed below show the current cooling system does not meet the cooling requirements with the 500 BHP engine at rated power and top speed in 115°F ambient temperature. The 115°F ambient test run could not be run because the water from the engine and engine oil sump temperatures would exceed their specified limits. The critical temperatures in parentheses are extrapolated to 115°F ambient air temperature

| Configuration | Ambient Temp °F | Water from Eng °F | Engine Oil Sump °F | Trans Oil to Cooler °F |
|---|---|---|---|---|
| III | 95 | 219.7 | 273 | 247 |
| III | 105 | 229.5 | 281 | 256 |
| III | 115 | (239.5) | (299) | (265) |

3.3 Fuel Consumption test results show either engine can meet 186 mile cruising range requirement.

3.4 Top Speed test results showed either engine can meet 38-mph top speed requirement.

3.5 See Appendix D for the Engine Product Qualification test results.

3.6 See Reference 1 for the Design of Experiment test results.

3.7 The TE/WT model, Appendix E, was validated with the Sprocket Power Test results.

3.8 The coolant mixing device improved the mixing of the coolant by 20%, however, it caused a rise in top tank temperature apparently from the drop in coolant flow brought about by increased restriction.

## 4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 The M109A6 Paladin SPH, in all configurations, was unable to comply with the cooling performance requirements at 0.35 TE/WT in 115°F ambient temperature. Additional testing showed the current cooling system is unable to cool the 500 hp engine at rated power top speed in 115°F ambient temperature. Recommend considering options to improve the cooling performance as discussed in Sections 9.0 of this report.

4.2 The TC-396 torque converter functioned similarly to the TC-360 torque converter during FLHACT which indicates its suitability as a replacement option. Durability testing is recommended prior to using the TC-396 torque converter in place of the TC-360.

4.3 During the FLHACTs, results show the ambient air (115°F) was increased by as much as 37°F before it reached the radiator. This hotter air then flows through the radiator and significantly degrades the cooling system heat rejection capability. A means of providing cooler air to the radiator would greatly enhance cooling performance.

4.4 A water pump from a DDC 8V92 engine can fit on a DDC 8V71T engine by making some revisions to the pump housing (see Appendix D). The pump was installed and a no-load flow test was run with the power pack out of vehicle. Results showed the coolant flow increases by 10% to 14% with the use of the 8V92 pump. This cooling pump would allow more cooling flow and possible cost savings from the reduction of unique parts. Recommend testing the 8V92 coolant pump installed in the vehicle prior to using it as a replacement.

4.5 While replacing the water pump, it was noticed that two lines going to the coolant overflow tank were reversed. Both these hoses have identical connectors. The reversed lines could cause air to be ingested into the cooling line. Recommend different sized connectors be used to avoid line reversal.

4.6 While checking for a radiator coolant leak, we found the seal in the top exhaust grille was allowing the exhaust gas to be re-circulated into the radiator depositing soot and causing wear on the radiator tubing and radiator cap. Recommend providing a sufficient gasket to prevent exhaust gas recirculation. Also the rubber hoses and caps near the right side of the radiator should be routinely checked and replaced if found to be hardening.

## 5.0 TEST EQUIPMENT AND PROCEDURE

The testing was conducted in TARDEC's Propulsion Systems Laboratory, Test Cell #9 Building 212. This large atmospheric test cell is capable of inducing a number of wind and temperature points. Cell temperatures can be controlled to range from ambient up to 160°F. Simulation of solar radiation is possible. Wind speed of up to 20 mph can be achieved from any of eight different directions. The dynamometers can absorb 128,000 ft-lbs of torque at stall. Figure 1 shows the Paladin set up for testing. The test plan and procedure are found in Appendix C.

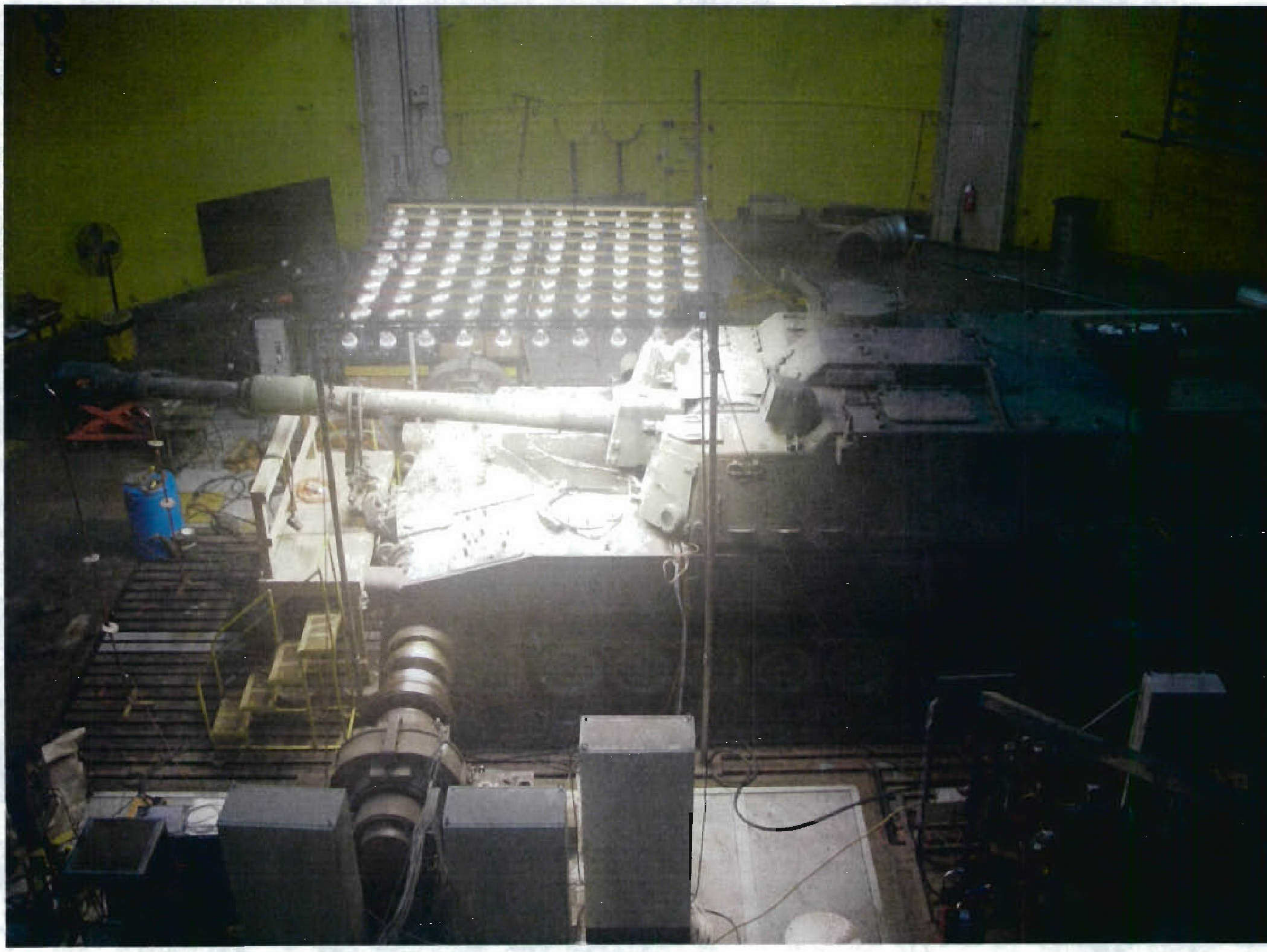

**Figure 1 – Paladin Installed in Test Cell #9, Building 212**

## 6.0 TEST MATERIAL

Figure 2 shows the Paladin cooling system schematic. Cooling air is drawn through the intake grilles by two gear driven fans. The fans draw air across the engine, through the radiator and out the exhaust grilles. The thermostat housing assembly is mounted externally from the engine, requiring additional pipes and coolant connections. Figure 3 and Figure 4 show different views of the pulled power pack. Table 1 shows the major test components included in each configuration.

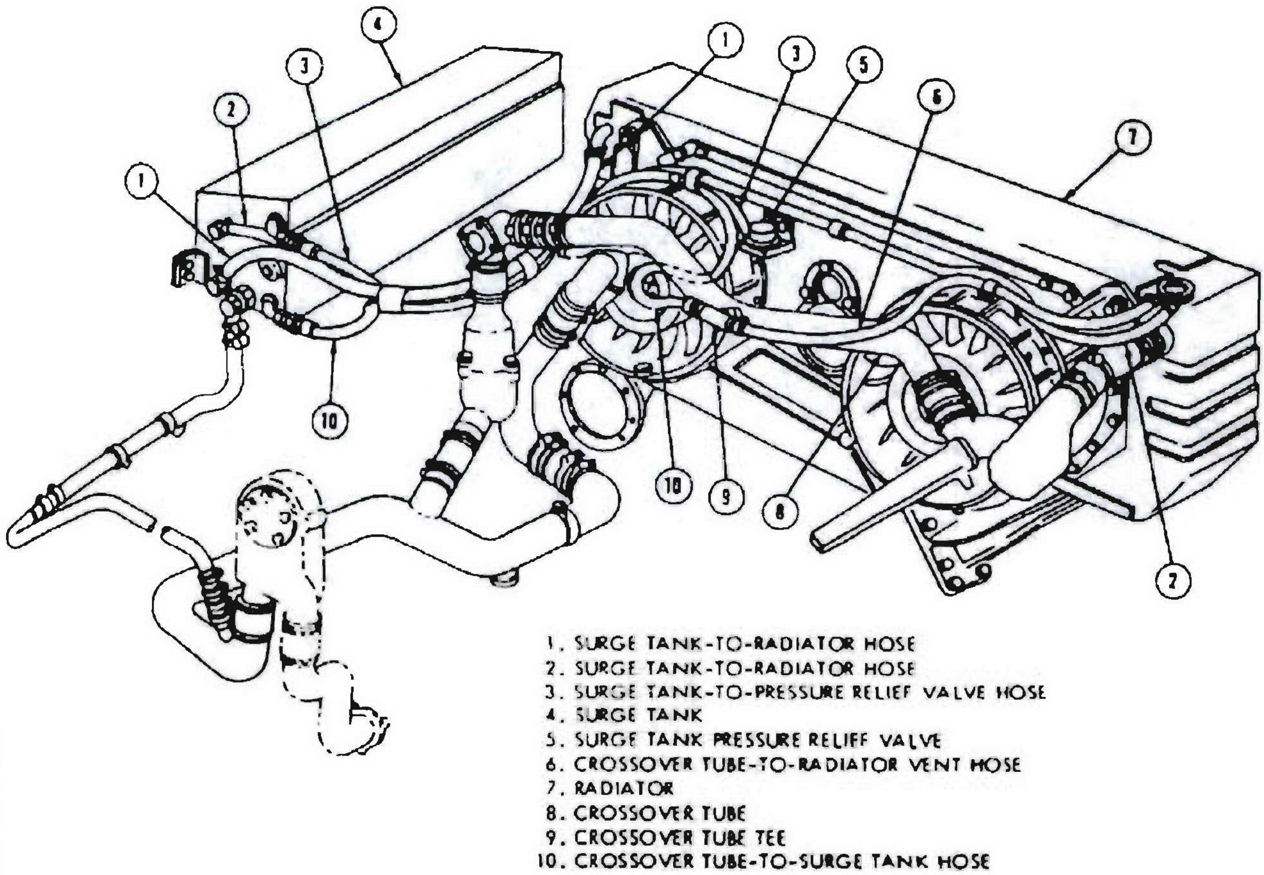


**Figure 2 – M109A6 Cooling System Components**

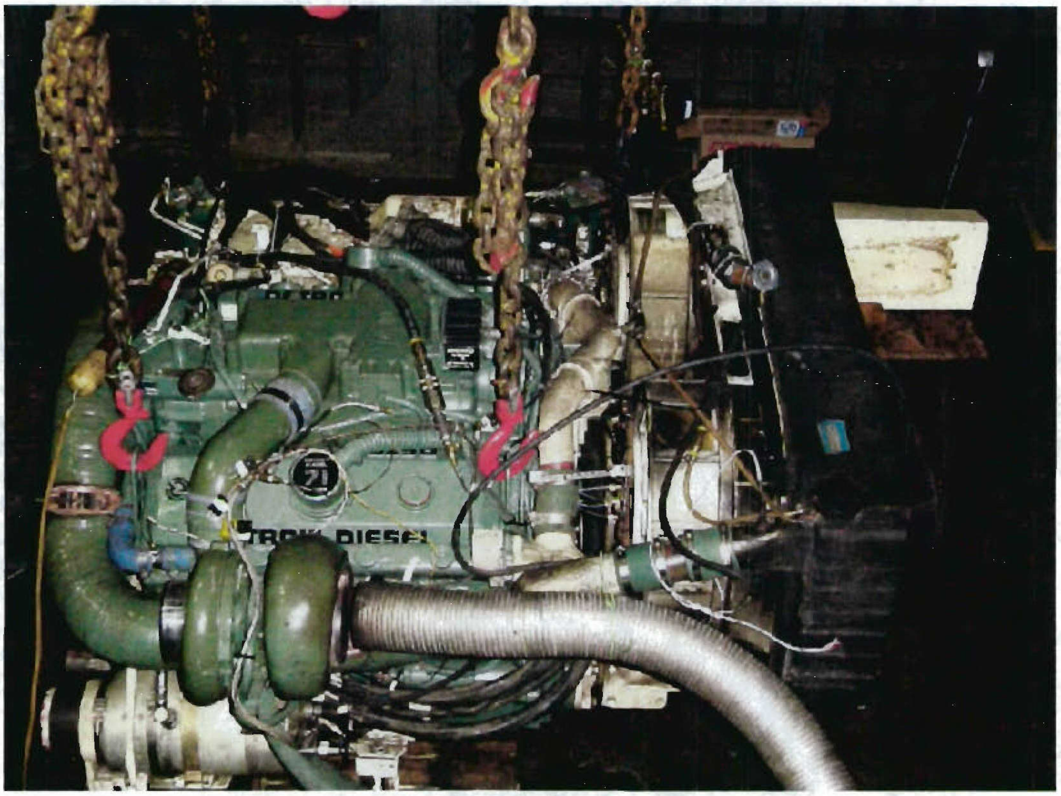

**Figure 3 – Top view of Pulled Power Pack**

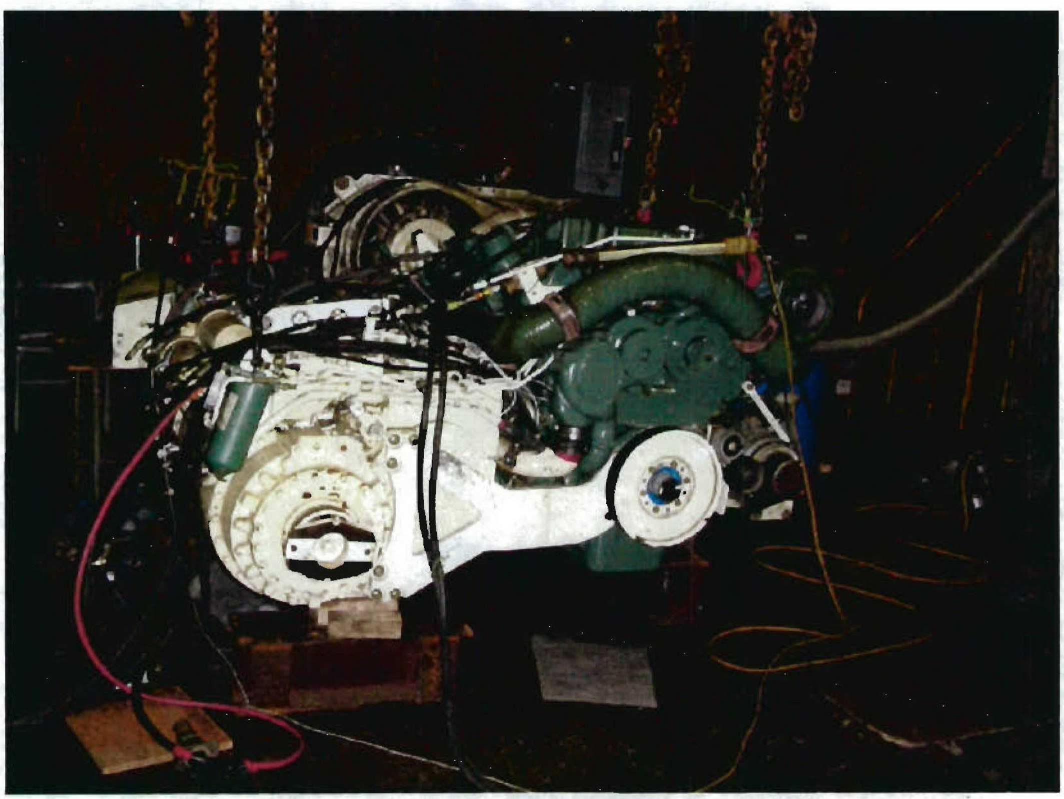

**Figure 4 – Side View of Pulled Power Pack**

Vehicle: M109A6 Paladin SPH, Army S/N 12A30966, Manufacture Date 7/92

| COMPONENT | CONFIGURATION I | CONFIGURATION II | CONFIGURATION III |
|---|---|---|---|
| ENGINE | Production Engine:<br>DDC 8V71T LHR<br>440 BHP @ 2300 rpm<br>7590 Injectors<br>36 tube oil cooler bundle | Same as Configuration I | Modified Engine:<br>DDC 8V71T LHR<br>500 BHP @ 2300 rpm<br>5228790 Injectors<br>42 tube oil cooler bundle<br>5101327 After cooler assembly |
| TRANSMISSION | Allison XTG411-4<br>4 forward speeds,<br>2 reverse speeds | Same as Configuration I | Same as Configuration I |
| TORQUE CONVERTER | Allison model TC360 | Allison model TC396 | Allison model TC396 |
| RADIATOR | Young Radiator Corp.<br>P/N 318399<br>S/N 2669107<br>Army P/N 12352900<br>Crossflow type<br>1 Pass<br>18"x47"x6" Core Size<br>11 fins/inch | Same as Configuration I | Same as Configuration I |
| FAN | Moda Magnetics Corp. Vane Axial Fan<br>P/N 12268231<br>S/N 0018<br>Blower, Axial<br>Two fan set side by side<br>17" Diameter<br>Venturi Shroud<br>Tip clearance approx .005<br>Direct gear driven off the Allison transfer case | Same as Configuration I | Same as Configuration I |
| TRANSMISSION OIL COOLER | Perfex Corp- Modine Shell Tube and Shell Type<br>42 Tube<br>Engine coolant cooled<br>Pressure side of engine water pump | Same as Configuration I | Same as Configuration I |
| THERMOSTAT | P/N19207-10921755-1<br>2 Bypass system<br>NSN 6620-00-810-3921<br>Opening temp 180°F<br>Blocked open during Test | Same as Configuration I | Same as Configuration I |

**Table 1 – Test Components used for Configurations I, II & III**

## 7.0 CONFIGURATION SPECIFIC DISCUSSION

### 7.1 CONFIGURATION I

This original configuration included the 440 BHP engine and TC-360 torque converter. Top speed, fuel consumption and some full load testing was done before it was discovered the water pump was leaking causing the cooling fluid to be low in the system. This was a problem because the radiator is the highest component in the cooling system, meaning that when there was low coolant, the radiator was low on coolant and the system's effectiveness was reduced.

During the replacement of the water pump it was noticed that two lines going to the coolant overflow tank were reversed based upon how the Technical Manual requires they be installed. It is unknown how long the lines were reversed but, based on the line marking procedure we use when pulling a power pack, the lines were reversed before the vehicle arrived. So, it is known that the vehicle is functional with reversed lines, but what is unknown is whether any adverse affects results from it. In theory, the reversed lines could cause air to be ingested into the cooling line, when in fact the purpose of these lines is to purge air from the system. Air is a much poorer cooling medium than water which is why it is purged from the cooling system. Both these hoses have identical connectors and both are ¼ inch in diameter. We recommend that different sized connectors be used to avoid this problem in the future. As is, this line switching mistake is easy to do and there are probably fielded units with the same issue. Figure 5 shows which two lines were reversed. Due to the unknown effects of the reversed lines and the potentially low coolant during the long duration tests, it was decided to rerun the gamut of tests to ensure validity of results.

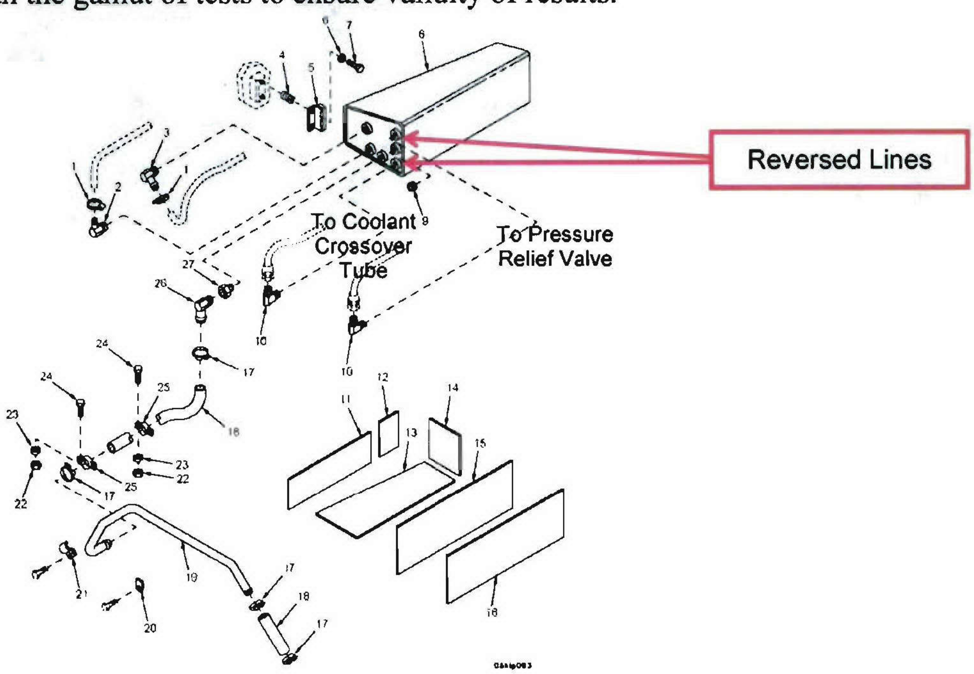


**Figure 5 – Reversed Lines into the Surge Tank**

Full load cooling tests were run at five different ambient temperatures, (77°F, 95°F, 100°F, 105°F and 115°F). These temperatures were picked for uniformity of spacing, every 10 degrees, and/or to match previous Yuma data for comparison purposes. Table 2 shows the critical temperature results from this testing. The tractive effort to weight ratio was based on a fully combat loaded 63,300 pound vehicle.

| | | CRITICAL TEMPERATURES | | |
|---|---|---|---|---|
| Ambient Temp °F | TE/WT | Coolant into Radiator °F | Engine Oil Sump °F | Trans Oil to Cooler °F |
| 95.2 | 0.30 | 201.6 | 249 | 224 |
| 95.1 | 0.33 | 199.9 | 244 | 218 |
| 95.2 | 0.35 | 193.9 | 235 | 208 |
| 95.4 | 0.45 | 208.5 | 248 | 237 |
| 95.1 | 0.50 | 209.9 | 247 | 240 |
| 95.2 | 0.55 | 212.7 | 250 | 246 |
| 95.0 | 0.60 | 215.5 | 252 | 253 |
| 100.3 | 0.41 | 214.2 | 255 | 243 |
| 99.9 | 0.55 | 217.1 | 254 | 250 |
| 100.3 | 0.60 | 221.2 | 257 | 260 |
| 100.6 | 0.61 | 222.7 | 258 | 263 |
| 104.9 | 0.26 | 212.6 | 260 | 235 |
| 105.7 | 0.31 | 209.8 | 254 | 228 |
| 105.6 | 0.32 | 209.6 | 253 | 226 |
| 105.5 | 0.33 | 209.0 | 251 | 224 |
| 105.3 | 0.40 | 218.9 | 259 | 248 |
| 105.4 | 0.45 | 220.2 | 259 | 249 |
| 105.5 | 0.50 | 221.6 | 258 | 253 |
| 105.7 | 0.55 | 224.6 | 261 | 261 |
| 106.0 | 0.60 | 227.9 | 263 | 269 |
| 117.4 | 0.31 | 222.9 | 265 | 240 |
| 116.5 | 0.32 | 222.3 | 264 | 238 |
| 115.7 | 0.33 | 221.9 | 261 | 236 |
| 115.0 | 0.35 | * | * | * |

**Table 2 – Configuration I FLCT Results – Summary of Critical Temperatures**

*The Paladin could not cool at the required 0.35TE/WT in 115F ambient temperature. At this test point, the temperature of the engine coolant rapidly increased to the spec. limit of 230°F and was still climbing so the test was stopped.

Figure 6 is a visual depiction of the engine coolant to radiator results obtained with Configuration I. The trend is very apparent and appears very steady as the ambient temperatures are increased. That is however, until the ambient temperature is 115°F.

There is a dramatic change in the ability of the vehicle to cool between 105°F and 115°F. What is being witnessed here is the topping out of the cooling systems ability to cool. The tractive effort to weight capability of the vehicle drops dramatically between 105 and 115 degrees. The vehicle can achieve 0.6 TE/WT at 105°F. But, at 0.35, the cooling point required in the spec, the vehicle temperatures would not even stabilize. It becomes very apparent how ambient temperature sensitive, the vehicle is in this range because a decrease in ambient temperature of only 1.5°F allows the vehicle to just barely stabilize at 0.40 TE/WT.

It is important to note, based on the required cooling point in the current Paladin specification, the vehicle does not achieve its TE/WT cooling point in its current (baseline) configuration. It does, however, come very close to making this point.

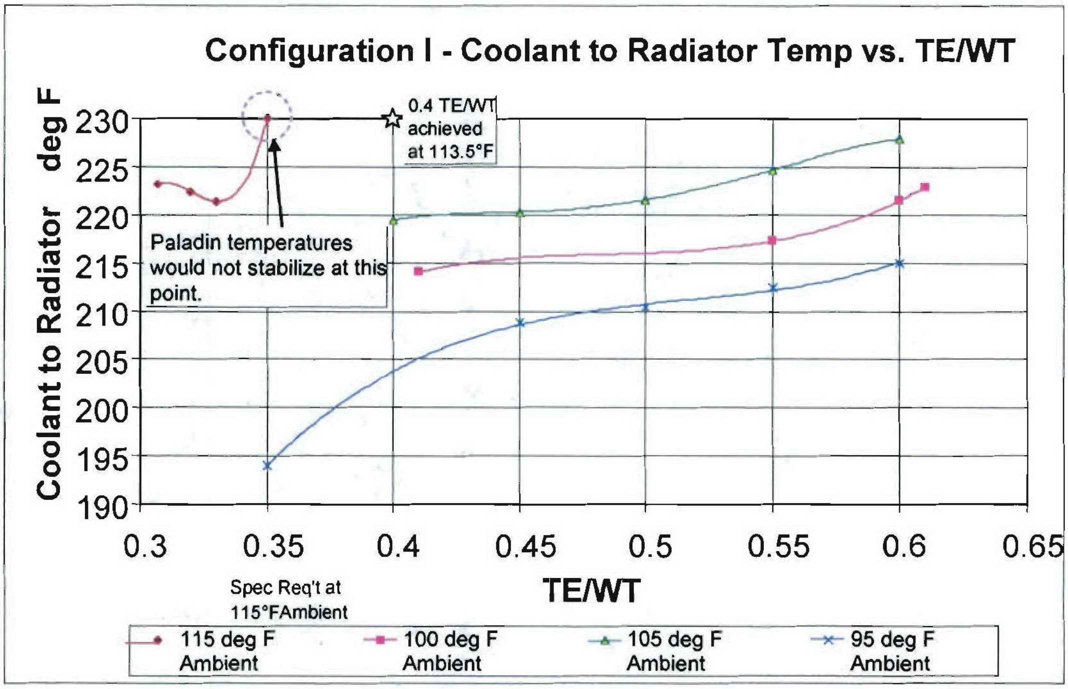


**Figure 6 – Graphical FLCT Results – Engine Coolant Temperature vs. TE/WT**

7.2 CONFIGURATION II

This configuration had the 440 horsepower engine and TC-396 torque converter. The TC-396 is made by ATD and is a replacement for the TC-360 that is currently the standard torque converter. The TC-396 torque converter was tested to determine if the TC-396 design will aid the overall vehicle's cooling ability. An increase in the efficiency of the torque converter will decrease the amount of heat into the oil. The TC-396 is a derivative of the M113 torque converter and can be produced when the TC-360 is discontinued.

The 440 BHP engine with the TC-396 torque converter did not significantly affect the cooling performance when compared to the baseline. Configuration II went into converter mode at 0.35 TE/WT same as the baseline which terminated the FLHACT. The power pack ran slightly hotter than the baseline (Figure 14) while in converter mode, a mode that works to increase the torque applied to the ground.

Table 3 shows the vehicle was not able to meet the specified cooling point in Configuration II. The point at which the torque converter drops into its converter mode falls around 0.35 TE/WT in 115°F ambient temperature. As the torque converter starts its job of multiplying torque there is a considerable amount of heat caused by torque converter slippage resulting in a rapid rise in the temperature of the engine coolant.

The characteristics of the power pack were changed slightly in Configuration II. For example, although the engine tended to run a little slower in converter mode with the TC-396 installed, it still achieved the same tractive effort points when compared to the engine with the TC-360 installed. This should provide a slight reduction in fuel consumption while hindering cooling ability a bit because of the direct mechanical linkage between the engine and fan. In essence, the TC-396 functioned as it should, not significantly better, nor significantly worse that the baseline TC-360. Durability was not tested during this program, but other than this open issue, the TC-396 is an acceptable replacement for the TC360.

| | | CRITICAL TEMPERATURES | | |
|---|---|---|---|---|
| Ambient Temp °F | TE/WT | Coolant into Radiator °F | Engine Oil Sump °F | Trans Oil to Cooler °F |
| 94.0 | 0.294 | 201.61 | 249 | 224 |
| 94.0 | 0.33 | 199.88 | 245 | 218 |
| 94.3 | 0.35 | 198.98 | 240 | 213 |
| 93.8 | 0.35 | 198.46 | 240 | 212 |
| 94.3 | 0.40 | 212.05 | 251 | 239 |
| 93.8 | 0.45 | 211.64 | 250 | 238 |
| 94.9 | 0.50 | 214.63 | 251 | 243 |
| 94.8 | 0.55 | 217.59 | 253 | 251 |
| 94.4 | 0.60 | 221.41 | 256 | 260 |
| 103.5 | 0.31 | 210.57 | 256 | 231 |
| 104.2 | 0.33 | 210.03 | 252 | 227 |
| 104.4 | 0.40 | 221.77 | 261 | 248 |
| 104.3 | 0.45 | 221.24 | 259 | 246 |
| 103.9 | 0.50 | 223.19 | 260 | 251 |
| 104.5 | 0.55 | 226.03 | 260 | 258 |
| 103.2 | 0.60 | 229.27 | 263 | 268 |
| 114.6 | 0.31 | 220.06 | 265 | 240 |
| 115.4 | 0.32 | 220.03 | 263 | 237 |
| 115.0 | 0.33 | 219.58 | 262 | 235 |
| 115.8 | 0.34 | 220.27 | 260 | 234 |
| 115.0 | 0.35 | * | * | * |

**Table 3 – Configuration II FLCT Results - Summary of Critical Temperatures**

*The Paladin could not cool at the required 0.35TE/WT in 115F ambient temperature. At this test point, the temperature of the engine coolant rapidly increased to the spec. limit of 230°F and was still climbing so the test was stopped.

## 7.3 CONFIGURATION III

This configuration included the 500 BHP engine with the TC396 torque converter. This 500 BHP engine is a modified form of the baseline engine. The modifications included the addition of an aftercooler and the incorporation of a higher capacity oil cooler and higher capacity fuel injectors. Figure 7 shows the up-powered engine prior to installation.

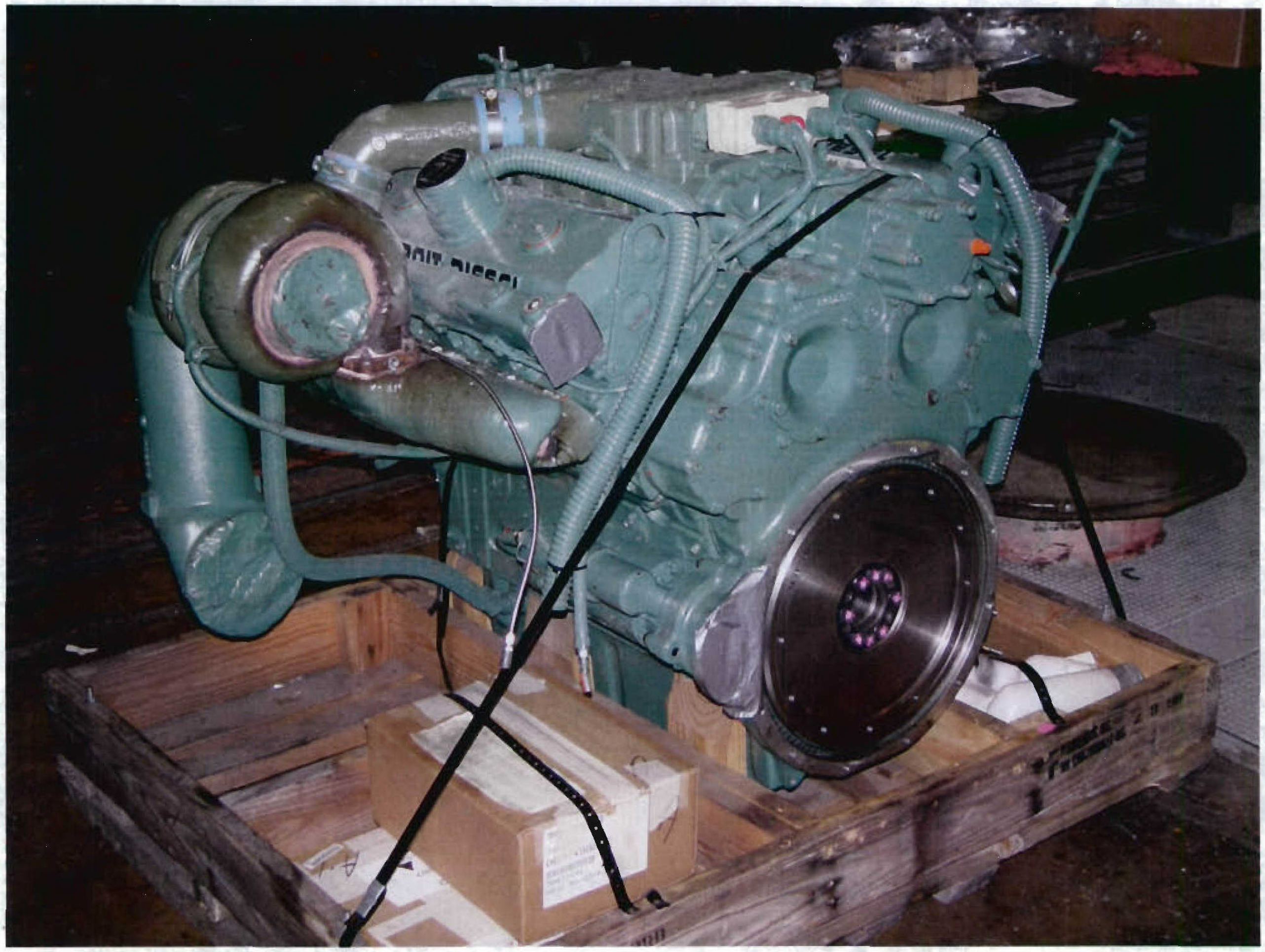

**Figure 7 – 500 Horsepower Detroit Diesel 8V71T Engine**

The FLHACT results, for Configuration III, are shown in Table 4. The vehicle in this configuration was able to keep the coolant to radiator temperature under the specification limit of 230°F at 0.35 TE/WT. However, the engine oil sump temperature exceeded the specification limit of 275°F by 10°F.

Permission was obtained from the engine manufacturer (Detroit Diesel Corporation), to increase the engine oil limit to 290°F for these tests only. While higher engine oil temperatures do not normally affect the ability of the engine to do its job, they will inevitably reduce engine life.

| | | CRITICAL TEMPERATURES | | |
|---|---|---|---|---|
| Ambient Temp °F | TE/WT | Coolant into Radiator °F | Engine Oil Sump °F | Trans Oil to Cooler °F |
| 95.0 | 0.30 | 212.86 | 271 | 233 |
| 95.1 | 0.33 | 212.99 | 270 | 233 |
| 95.2 | 0.35 | 210.64 | 267 | 229 |
| 95.5 | 0.37 | 208.14 | 263 | 222 |
| 95.2 | 0.45 | 221.32 | 274 | 248 |
| 95.2 | 0.50 | 221.62 | 274 | 248 |
| 95.5 | 0.55 | 223.62 | 275 | 253 |
| 95.3 | 0.60 | 226.43 | 277 | 260 |
| 105.5 | 0.30 | 221.09 | 278 | 242 |
| 105.2 | 0.33 | 220.80 | 276 | 240 |
| 104.7 | 0.35 | 218.57 | 273 | 236 |
| 105.5 | 0.37 | 216.07 | 270 | 230 |
| 105.2 | 0.45 | 228.99 | 280 | 255 |
| 105.7 | 0.50 | 229.62 | 280 | 256 |
| 115.6 | 0.35 | 229.58 | 285* | 245 |
| 115.0 | 0.37 | 227.22 | 280* | 239 |

**Table 4 – Configuration III FLCT Results - Summary of Critical Temperatures**

* Exceeds the Engine Oil Sump Temperature limit of 275°F

There appears to be no single factor that allowed the vehicle to keep its engine coolant temperature under 230°F in this configuration, rather it is a cumulative affect of different operating characteristics along with the addition of a more efficient torque converter.

The use of a higher power engine effectively changed the engine operating points at which different tractive effort to weight points are achieved. For example, the engine speed required to make the 0.35 tractive effort to weight point is higher under this configuration than the previous two configurations. The fan drive is mechanically linked to the engine such that the higher the engine speed, the faster the fans spin and the more cool air they push through the radiator. Higher engine speed also correlates to higher coolant flow rates. This is especially prevalent on the 500 HP engine since the coolant flow rate has been increased over the whole spectrum by about 10 gallons per minute. Because of this, the coolant flow at the same tractive effort points in Configuration III was higher. The upward trend of coolant flow based on engine speed and the jump up for the 500 HP engine is shown visually in Figure 9. The difference in coolant flow rates at the same tractive efforts between the three configurations is shown in Figure 10.

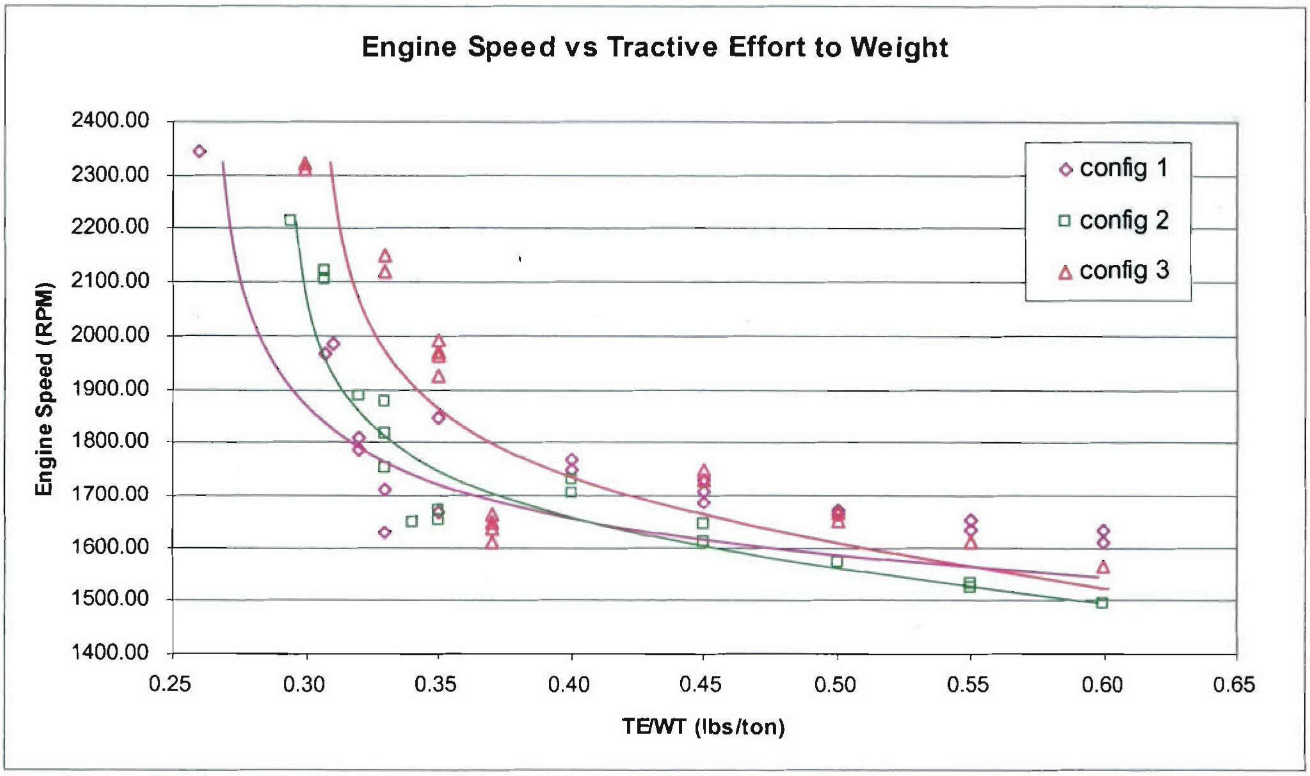


**Figure 8 – Engine Speed at Various TE/WT Points**

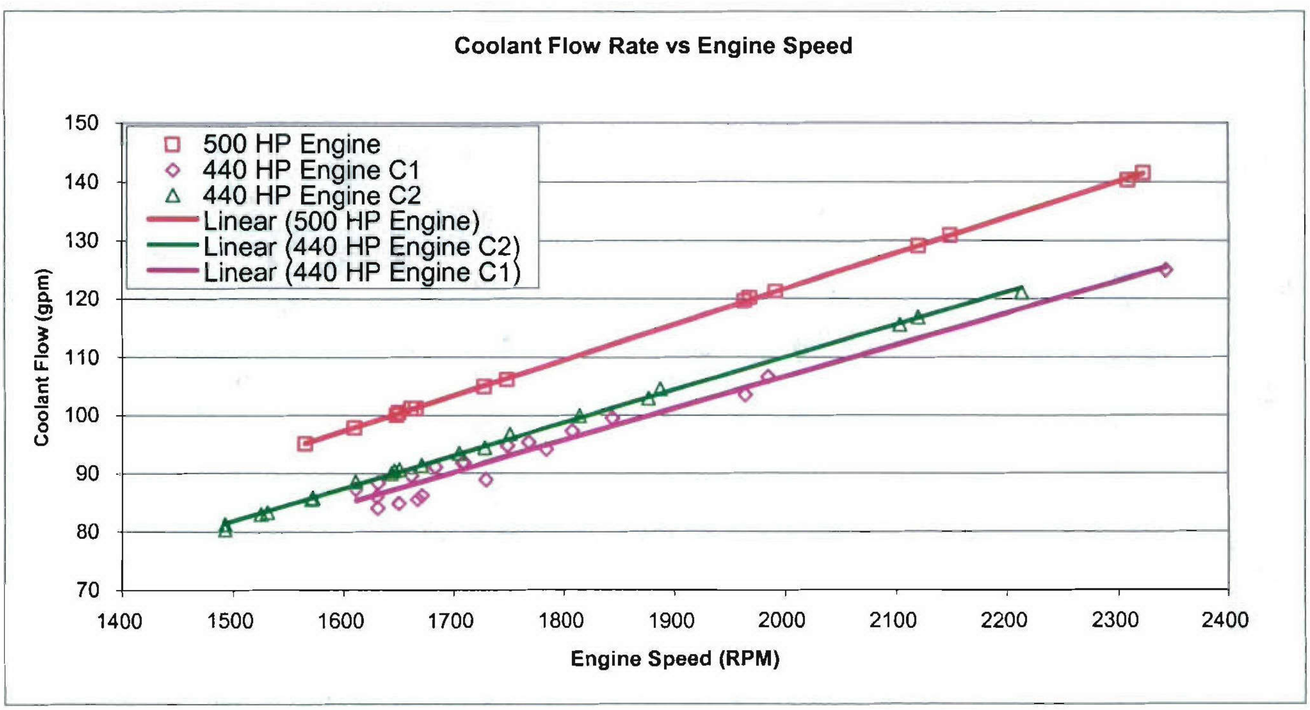


**Figure 9 – Coolant Flow Rate Increases Linearly with Engine Speed**

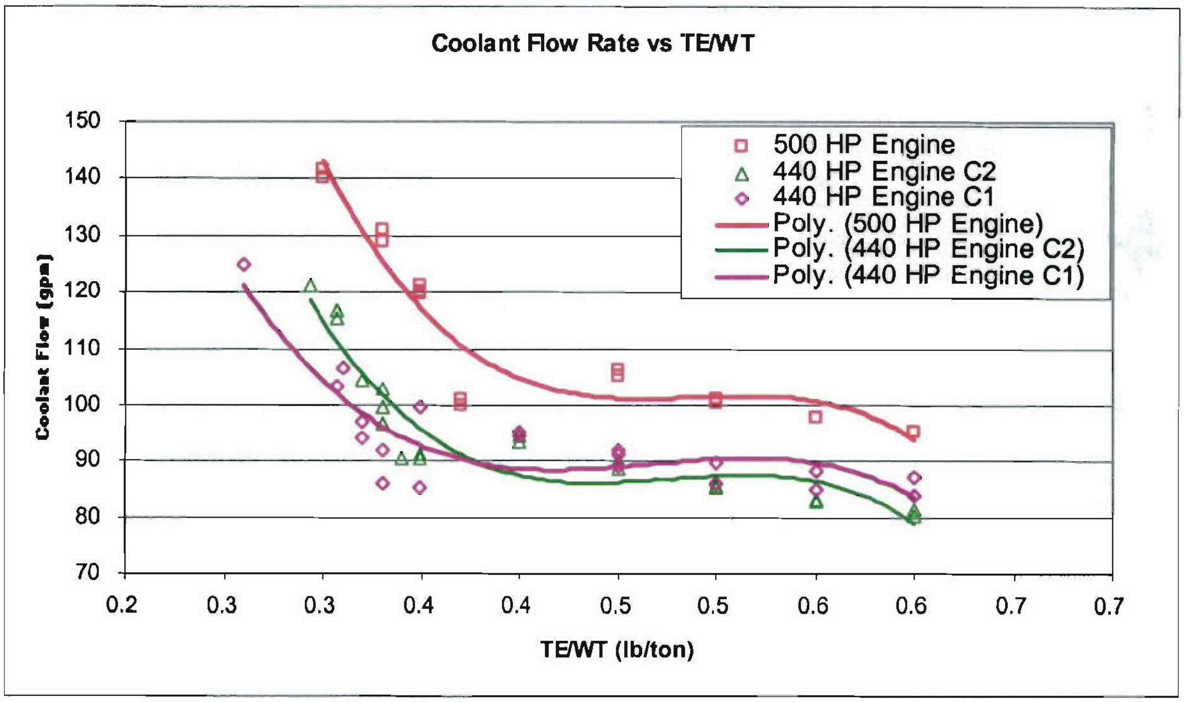


**Figure 10 – Configuration III has a Higher Flow Rate at the same TE/WT Point**

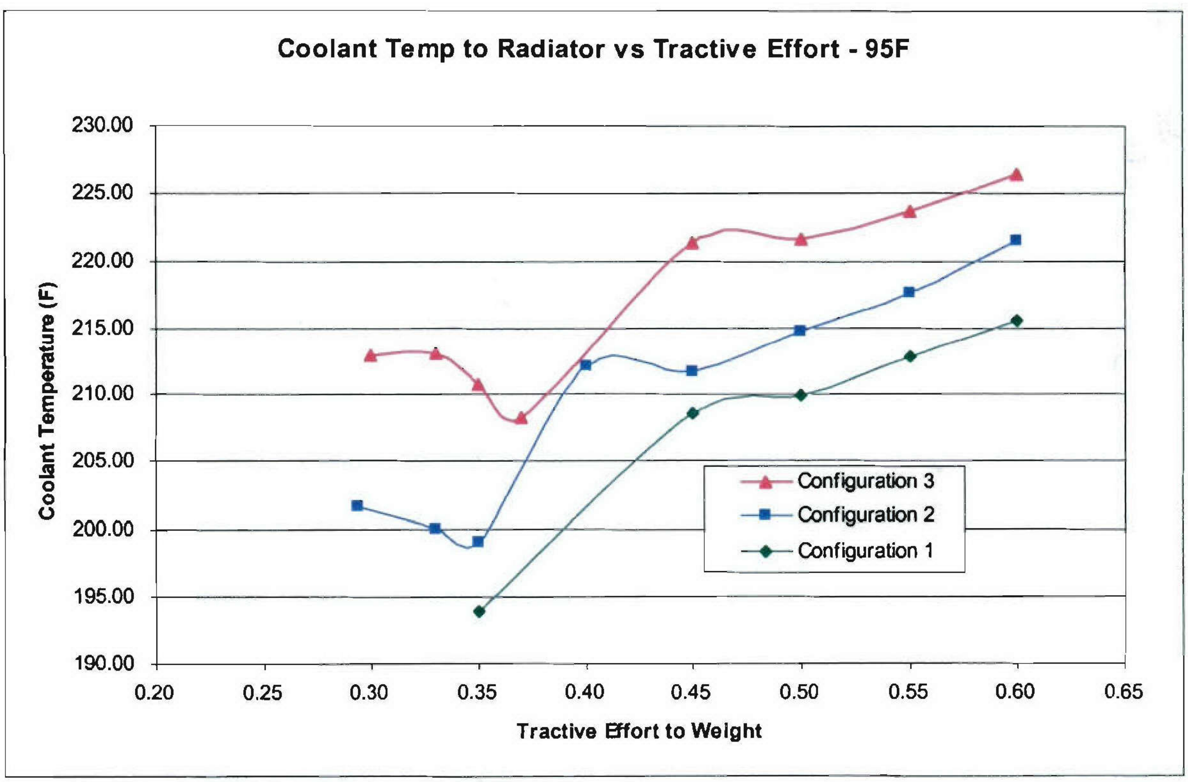


**Figure 11 – Top Tank Temperature at Given TE/WT**

## 8.0 GENERAL DISCUSSION

### 8.1 FULL LOAD COOLING TESTS

The FLHACT and Max HP Top Speed test results are shown in Table 5. The Maximum Hp Top Speed tests were run in 95°F and 105 °F ambient temperatures.

| BHP/Torque Converter | 440/TC-360 | | 440/TC-396 | | | 500/TC-396 | | | |
|---|---|---|---|---|---|---|---|---|---|
| Test Run | 12/10/03 | | 2/5/04 | | | 4/14/04 | | 05/03/04 | |
| TE/WT (or Max Hp Top Speed ) | 0.31 | 0.33 | 0.31 | 0.33 | 0.34 | 0.35 | 0.37 | Max HP TSpeed | Max HP TSpeed |
| Ambient Temp | 117.4 | 115.7 | 114.6 | 115.0 | 115.8 | 115.6 | 115.0 | 95.6 | 105.1 |
| Speed ratio | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.169 | 0.169 |
| Engine Speed RPM | 1965 | 1630 | 2120 | 1751 | 1646 | 1925 | 1610 | 2298 | 2299 |
| Sprocket speed RPM | 96.5 | 80.1 | 103.9 | 86.2 | 80.7 | 94.8 | 79.3 | 664.0 | 665.5 |
| Sprocket Torque FT-LB | 15873 | 17062 | 15704 | 17305 | 17717 | 18289 | 19234 | 4066 | 3564 |
| Calculated Sprocket HP | 291.6 | 260.3 | 310.7 | 284.0 | 272.3 | 330.1 | 290.3 | 514.0 | 451.6 |
| Coolant flow GPM | 103.4 | 86.0 | 116.7 | 96.7 | 90.4 | 118.0 | 98.8 | 140.0 | 140.0 |
| Coolant Into Radiator °F | 222.9 | 221.9 | 220.1 | 219.6 | 220.3 | 229.6 | 227.2 | 219.7 | 229.5 |
| Coolant Out of Radiator °F | 209.6 | 208.1 | 207.8 | 206.6 | 207.0 | 218.1 | 214.2 | 206.3 | 216.2 |
| Transmission Oil to Clr °F | 239.6 | 235.7 | 239.9 | 235.2 | 234.0 | 245.5 | 239.4 | 247.1 | 256.2 |
| Engine Oil Sump °F | 265 | 261 | 265 | 261 | 260 | 285* | 280* | 273 | 281* |
| Avg Air out of Inlet grille °F | 124.0 | 123.1 | 121.4 | 122.4 | 123.5 | 120.0 | 119.6 | 98.8 | 108.4 |
| Avg Air To Fan °F | 139.2 | 139.0 | 138.2 | 139.4 | 140.6 | 143.0 | 143.1 | 125.1 | 135.1 |
| Avg Air into Radiator °F | 151.1 | 148.6 | 149.2 | 147.8 | 148.4 | 151.7 | 149.8 | 133.8 | 143.5 |
| Avg Air out of Radiator °F | 179.6 | 180.7 | 176.0 | 177.8 | 179.2 | 183.7 | 183.9 | 170.5 | 179.0 |
| Avg Air to exit grille °F | 194.4 | 195.9 | 191.0 | 193.0 | 194.8 | 200.7 | 201.1 | 184.0 | 194.5 |
| Avg Inlet Grille ΔP "H2O | 0.89 | 0.60 | 1.02 | 0.68 | 0.60 | 0.85 | 0.59 | 0.36 | 0.34 |
| Engine Comp. ΔP "H2O | 1.56 | 1.11 | 2.00 | 1.43 | 1.26 | 1.80 | 1.21 | 1.37 | 1.38 |
| Fan ΔP "H2O | 8.63 | 6.07 | 10.32 | 7.21 | 6.35 | 7.88 | 5.93 | 4.34 | 4.44 |
| Radiator ΔP "H2O | 5.02 | 3.63 | 5.87 | 4.20 | 3.74 | 4.00 | 3.41 | 7.54 | 7.49 |
| Exit Grille ΔP "H2O | 1.52 | 1.05 | 1.61 | 1.11 | 1.10 | 1.59 | 1.04 | 0.97 | 0.93 |
| Cal. Heat Rejection BTU/MIN | 11005 | 9559 | 11511 | 10074 | 9599 | 10848 | 10285 | 15049 | 14827 |
| Cal. Air Mass Flow** LB/MIN | 1604 | 1242 | 1786 | 1400 | 1296 | 1413 | 1258 | 1709 | 1743 |
| Cal. Rad Coolant ΔT °F | 13.27 | 13.85 | 12.29 | 12.99 | 13.23 | 11.46 | 12.98 | 13.40 | 13.20 |

**Table 5 – FLHACT and Max HP Top Speed Tests Results**

*Exceeds critical temperature limit of 275°F
**Total Air Flow for two fans

The critical temperatures from the FLHACT for Configurations I, II and III are graphically shown in Figure 12. At the required cooling point of 0.35 TE/WT, both Configurations I and II exceeded the engine coolant specified temperature limit before stabilization occurred. When comparing the stabilized TE/WT runs completed for Configurations I and II, there was no significant difference in the engine oil sump and the transmission oil to cooler temperatures. Configuration II had a slight drop in engine coolant temperature before the radiator. The results show Configuration III met both the engine coolant and transmission oil critical temperature limits. However, the engine oil was running above the required 275 °F temperature limit by 5 °F to 10°F.

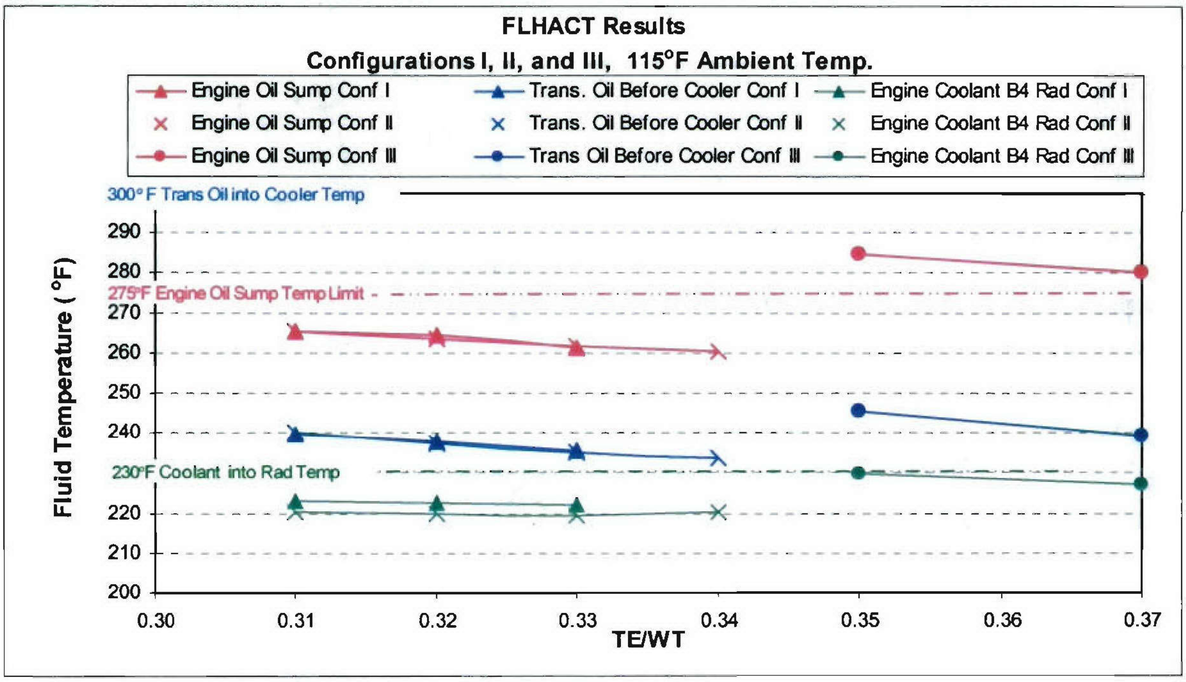


**Figure 12 – Critical Temperatures from FLHACT Results at 115°F**

Figure 13 shows the critical temperatures from the Rated Power Top Speed testing ran on Configuration III. These tests were run in two ambient temperatures 95°F and 105 °F. The vehicle at 95 °F was able to keep the critical temperatures within specified limits. However, at 105 °F the engine coolant was at the temperature limit of 230 °F and the engine oil sump exceeded the specified limit of 275°F by 7°F. From these results, it was concluded both the engine coolant and the engine oil sump temperatures would exceed their limits.

Figure 14 shows the critical temperatures during FLCT at 105°F ambient temperature. The engine oil has exceeded the 275°F limit in 105°F ambient temperature and the engine coolant is right at the 230°F limit.

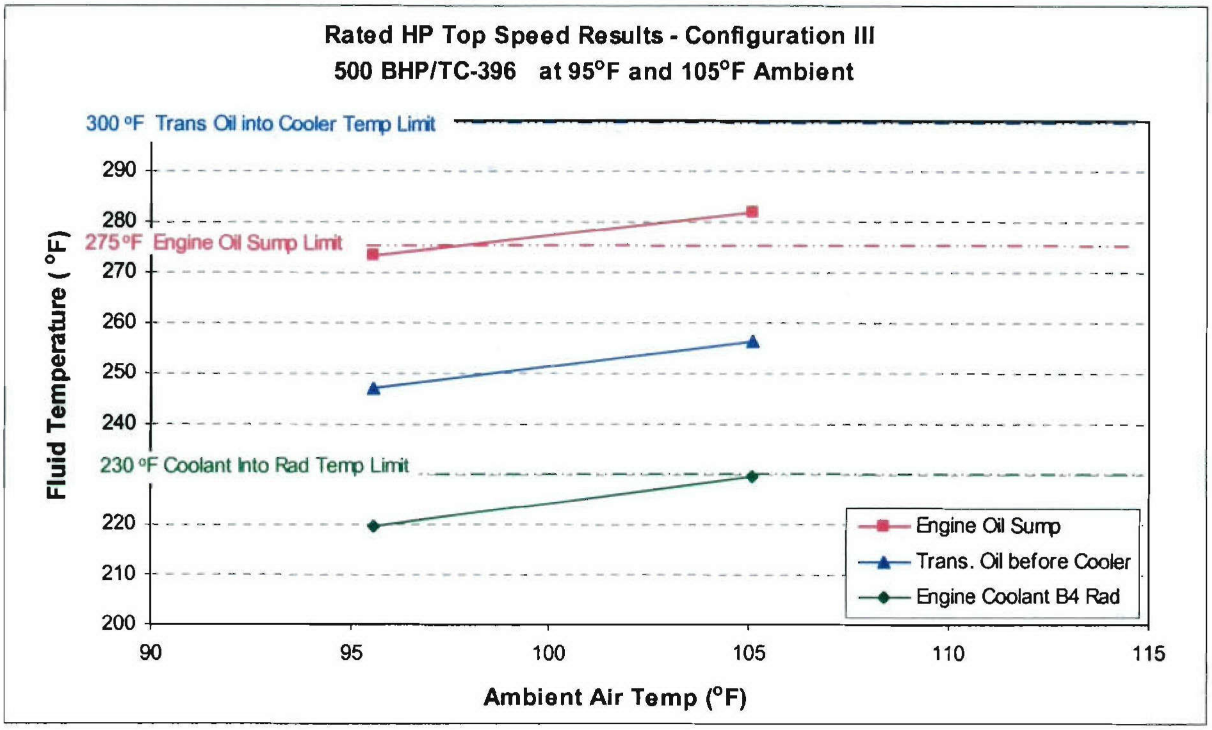


Figure 13 – Critical Temperatures from Rated Power Top Speed Test Results

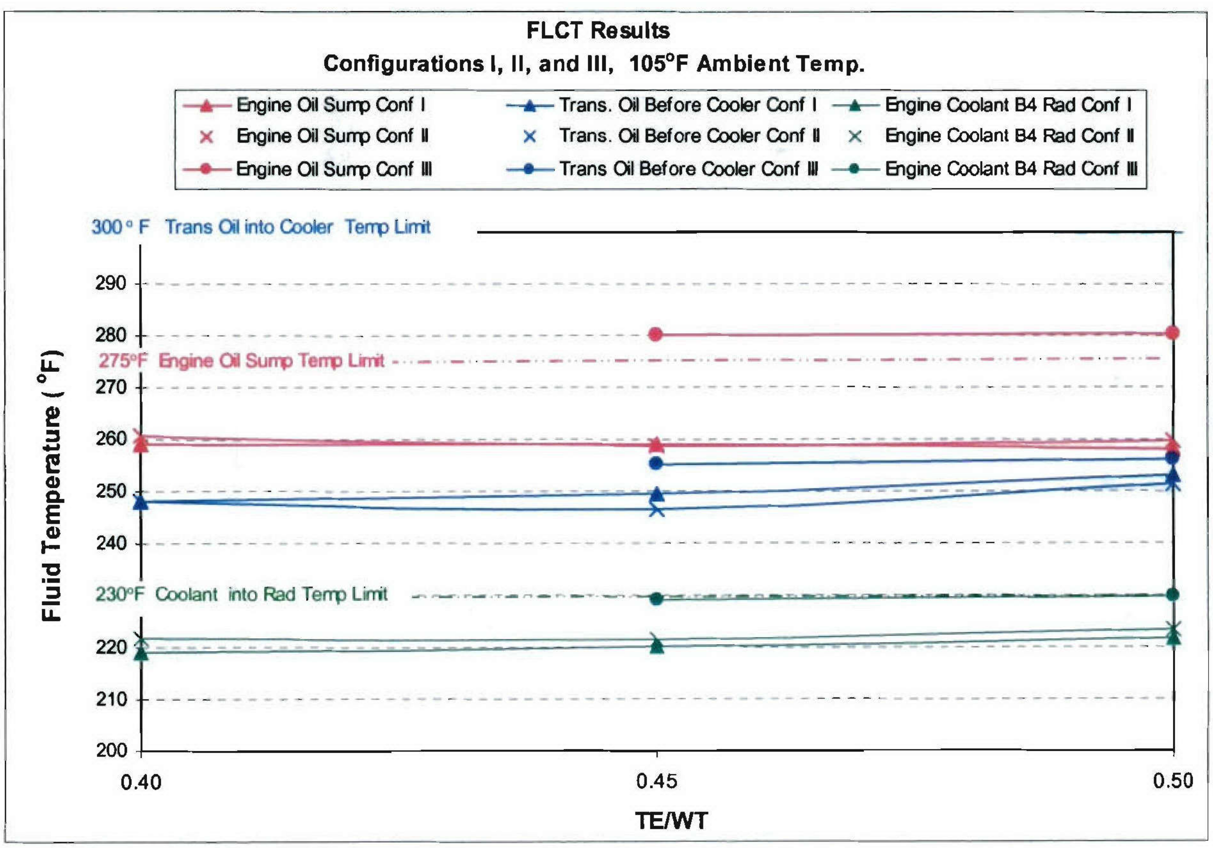


Figure 14 – Critical Temperatures from FLCT Results at 105°F

## 8.2 FUEL CONSUMPTION TESTS

The results, shown below, demonstrate the Paladin can exceed the cruising range requirements stated in MIL-H-71000A, Section 3.15.4.

| Configuration | DF-2 Cruising Range | JP-8 Cruising Range | Spec. Requirement |
|---|---|---|---|
| I - 440 BHP TC360 | 258 miles | 245 miles | 186 miles |
| III - 500 BHP TC396 | 283 miles | 255 miles | 186 miles |

The M109A6 Vehicle specification calls for the vehicle to have a minimum cruising range of 186 miles when operated on primary roads at 25 mph. This requirement can be broken down into two components, 1) the steady state fuel consumption of the engine at 25 mph on a primary road, and 2) the size of the fuel tank. These two items are related and must be balanced so the range can be reached. The more fuel the engine uses, the bigger the fuel tank and vice versa. In the case of the Paladin, the fuel tank size is known, 133 gallons, and only the fuel consumption rate needs to be determined.

Based on the requirement, testing performed on the vehicle simulated the operation of a 63,300 pound M109A6 on a primary road (a rolling resistance of 85 lb/ton) while also accounting for the wind resistance that would normally be encountered while traveling at 25 mph. The dynamometer was loaded down based on these characteristics, thus replicating the operating condition that would be experienced in the real world, while keeping the vehicle securely tied to the floor and hundreds of channels of instrumentation easily recording data. Testing was done with DF-2 diesel fuel as well as JP-8 turbine fuel. JP-8 is the standard fuel the Army likes to use since it is common with the Air Force. A diesel engine will operate on either fuel. This test was conducted on the 440 horsepower engine and the 500 horsepower engine, Configurations I and III respectively.

Operating for 186 miles at a cruising speed of 25 mph equates to 7.44 hours of operation. Tests were run at steady state to determine the fuel consumption rate per hour. The fuel used during one hour was projected into the weight of fuel that would be consumed during 7.44 hours (186 miles) of operation. During testing, the fuel consumed, by weight, for JP-8 and DF-2 was similar within each test configuration. This is where the similarities end. The density of the two fuels is different. DF-2 is heavier, at 7.111 lb/gal, than JP-8 which only weighs 6.673 lb/gal. The weight of fuel, divided by the density of fuel, equates into the volume of fuel used, or gallons, which can be compared to the size of the existing fuel tank to determine spec. compliance. Because of the different densities, dividing the weight, which was similar between JP-8 and DF-2, by the density led to different volumes of fuel being consumed between JP-8 and DF-2. What was found was that the volume of DF-2 required was less than the volume of JP-8 required (see Table 6) for the same 7.44 hours (186 miles) of operation.

DF-2 is a denser fuel so more power is derived per volume, and less volume is required to achieve the same range. Even though JP-8 required more fuel to achieve the 186 mile range, it did not exceed the capacity of the fuel tanks, which can carry 133 gallons. So, using either JP-8 or DF-2, the fuel consumption requirement is satisfied.

| Configuration | DF-2 | | JP-8 | |
|---|---|---|---|---|
| | Fuel Used (gallons) | Miles Achieved per Gallon | Fuel Used (gallons) | Miles Achieved per Gallon |
| I - 440 BHP TC360 | 96 | 1.94 | 101 | 1.84 |
| III - 500 BHP TC396 | 87 | 2.13 | 97 | 1.92 |

**Table 6 – Fuel Volume Required to Achieve 186 Mile Range at 25 mph**

In addition to satisfying the cruising requirement, all configurations tested had fuel remaining in the tanks at the end of the cruise duration. This provides fuel to conduct limited operations at the end of the cruise operation or to cruise further. If 5% of the fuel is to remain in the tank (a fuel tank should never be run completely empty as sediment accumulated in the tank will begin to enter the fuel pump and cause damage at extremely low fuel levels) the vehicles, depending on the configuration and type of fuel used, will have an additional cruise range of between 46 and 83 miles.

While a fuel map was not run on the two engines, it is worth noting that the fuel consumption, both of DF-2 and of JP-8, was reduced when the 500 horsepower engine was used. While it is possible that this may be an anomalous point, it is highly likely that the 500 horsepower engine will be more fuel efficient than the 440 horsepower engine over a wide range of operating conditions.

## 8.3 MAXIMUM SPEED TESTS

The results, shown below, comply with the requirement stated in MIL-H-71000A, Section 3.15.5.1.

| Configuration | Test Results | Spec. Requirement |
|---|---|---|
| I - 440 BHP TC360 | 38 mph | 38 mph |
| III - 500 BHP TC396 | 39.5 mph | 38 mph |

The up-powered engine produced for the Paladin generates 60 more horsepower than the 440 horsepower conventional engine it is intended to replace. Used efficiently, this power can be transferred directly to the tracks to provide for a higher top speed. In the case of the Paladin vehicle on test, of the 60 additional horsepower generated by the engine, at the tracks, only 15 additional horsepower is produced. This is the horsepower that is actually used to increase the vehicle's top speed.

The maximum speed test is an attempt to push the engine as far as it will go, to max out its speed generating potential. As a vehicle goes faster, the forces opposing its motion increase. A military vehicle is not very streamlined in design so considerable wind resistance force is exerted upon it when the vehicle is moving at fast speeds. The force exerted increases as a square of the vehicle speed. Figure 15 illustrates the impacts of wind resistance force on the vehicle speed. Figure 15 also shows that it takes 20 mph for the first 100 pounds of resistance, but only 10 more mph for the next hundred pounds of resistance.

Laboratory testing showed that the average speed increase from the 440 HP engine to the 500 HP engine was 1.4 MPH. The vehicle with 440 HP engine attained just under 38 mph. The vehicle with the 500 HP engine attained slightly over 39 mph. The wind resistance force of the vehicle is roughly 313 and 330 pounds respectively. This is a small percentage, 12%, of the force exerted against the vehicle by its movement across the ground, commonly known as the rolling resistance force. The Paladin experiences 2,690 pounds of rolling resistance force. The wind resistance force and rolling resistance force were determined based on the assumptions in Figure 16.

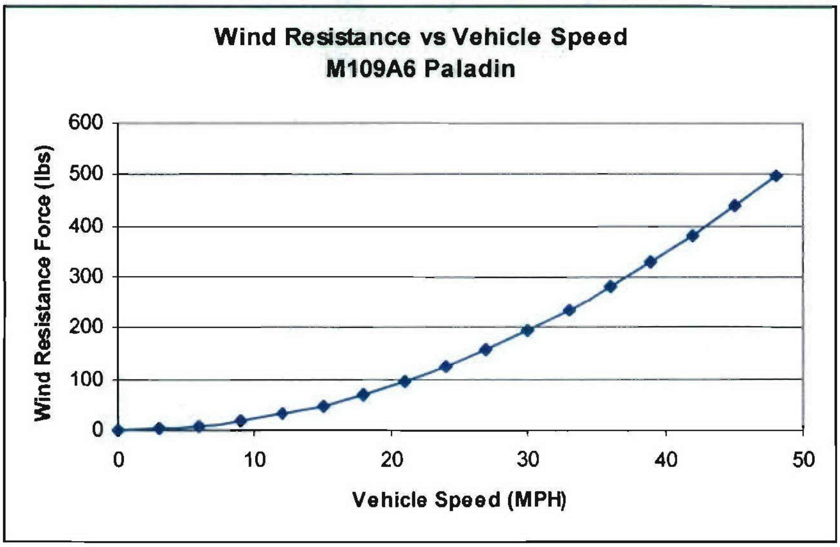


**Figure 15 – Wind Resistance Force Acting Against the Paladin**

| |
|---|
| Assumptions: |
| Coefficient of Drag: 0.8 |
| Density of Air: 0.075 $lb_M/ft^3$ |
| Vehicle Frontal Area: 108 $ft^2$ |
| Gross Vehicle Weight: 63,300 lbs |
| NRMM Rolling Resistance: 85 lb/ton |
| Percent Grade: 0% |

**Figure 16– Assumptions Used for Resistance Calculations**

The vehicle specification requires that the M109A6 be capable of achieving a top speed of 38 mph. Test done found that the baseline vehicle is capable of achieving a top speed averaging just under 38 mph. It is very close to the spec. requirement and during one individual run the speed did make the 38 mph requirement. The 500 HP based vehicle was able to achieve averaged speeds of slightly over 39 mph. Additionally, all individual tests in this configuration exceeded the 38 mph requirement. The 60 additional horsepower has bought 1.5 mph of top speed improvement (on a nice, hard, concrete paved, road). Taken by itself this is not very impressive. However, this extra horsepower should help the vehicle accelerate faster, though the dynamometers used for this test cannot measure acceleration. The heavy weights, and inertia, of the gearboxes tend to damp out a vehicle's response to increases and decreases in throttle.

## 8.4 AIRFLOW TEMPERATURE ANALYSIS

During FLHACT, irrespective of the configuration, we found there was a hot spot in the cooling airflow temperatures by the left cooling fan. As part of our instrumentation, we placed thermocouples (instruments that measure temperature) at many locations throughout the power pack, but put a significant amount in the airflow stream through the cooling components. Figure 17 shows the location of the instrumentation points. The two circles in the figure represent the cooling fans, while the rectangle represents the radiator they sit in front of. From this perspective, the engine would be in front of the page and the air exit behind the page. The circles with "1" and "5" in them are just beneath the deck armor. Each of the ten points represents the location of a thermocouple.

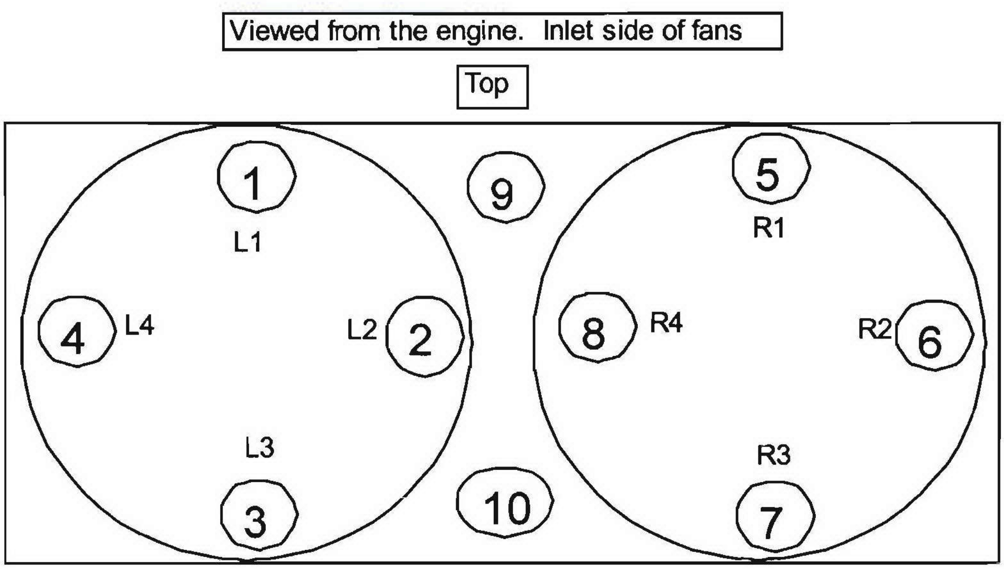


**Figure 17– Instrumentation Points in the Cooling Air Stream**

Data was recorded at these points over the entire test, all three configurations. We found that the air temperatures at the ten test locations were relatively stable through all three configurations (Figure18 and Figure 19). What we noticed was that location L3, left fan, 3rd position, was significantly hotter, approximately 30% hotter, under all configurations tested. It did not matter what the ambient temperature was, the trend was consistent. In Figure 18, the temperature spike at this point can be easily seen, as it rises at least 20 degrees over the other locations.

Based upon this, the conclusion can be drawn that either there is a very hot component nearby or that this is dead space, essentially an area with reduced airflow. From the photos (Figure 21 and Figure 22) which show the left cooling fan and the area around it, it is easily visible as to how the area around the bottom of the fan is clogged with tubing that is hindering airflow through the area. (NOTE: The clear tubing running around the inner circumference of the fan is for pressure taps for test purposes only). From looking at what components are in the area, and by physically touching these components, hot components are not the issue here. Rather, it is the very tight space which is causing a dead zone in air flow.

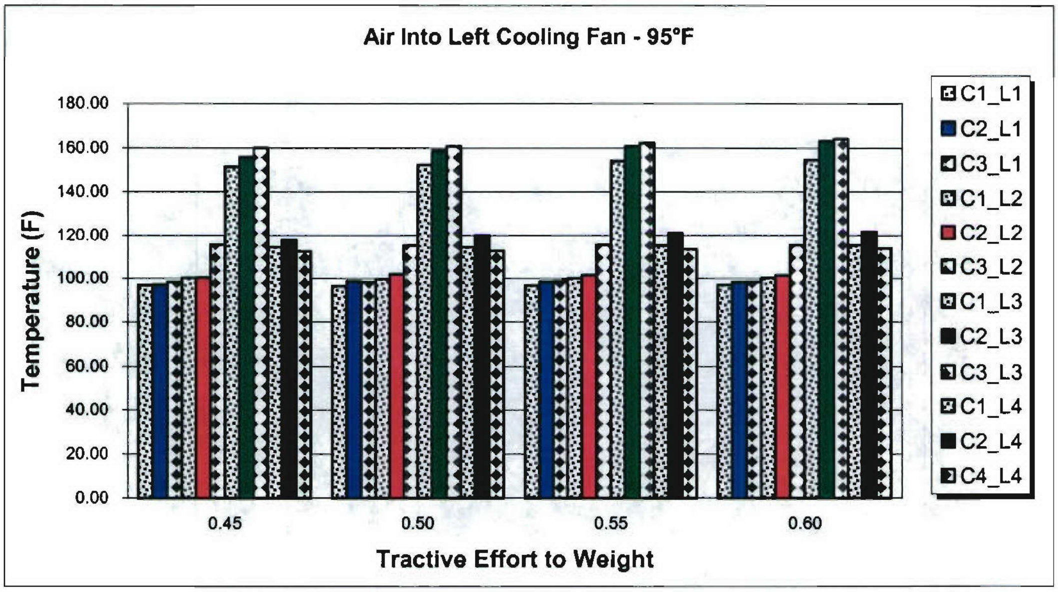


**Figure 18 – Temperature Profile of Left Cooling Fan**

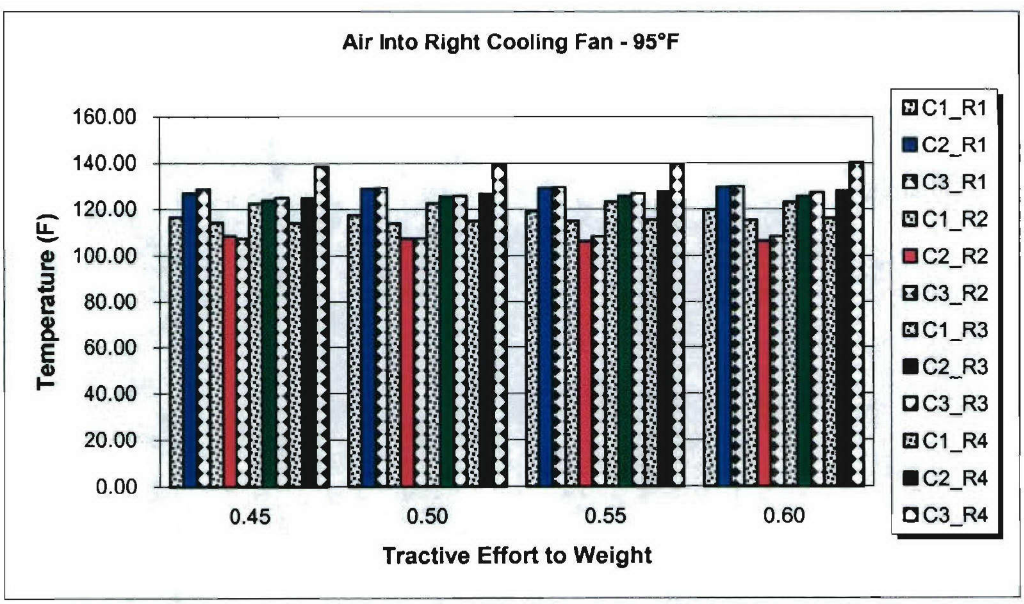


**Figure 19 – Temperature Profile of Right Cooling Fan**

**Figure 20 – Top View of Engine Compartment**

**Figure 21 – Center View of Left Cooling Fan, as Installed**

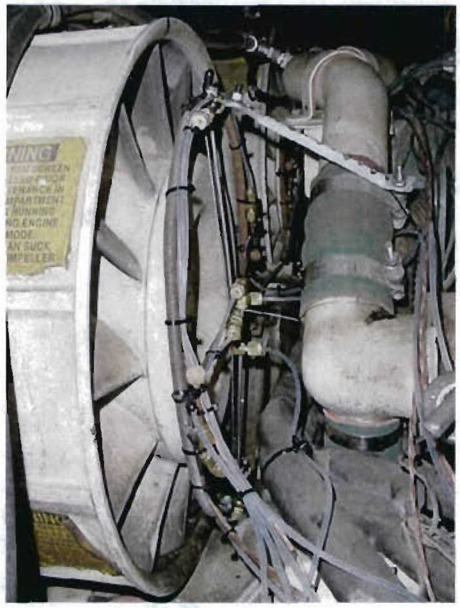


**Figure 22 – Side View of Left Cooling Fan, as Installed**

The existence of poor air flow at this point means that less air (and hotter air) is flowing through the radiator in this location. The larger the temperature difference between the cooling air and the cooling fluid, the more effective the radiator is at doing its job. Take the air temperature difference illustration shown in Figure 23. It shows that at 115°F, the worse case scenario, the temperature difference across the radiator is only about 12°F at this point, whereas, for all the other points it is at least 20°F. This air Delta T across the radiator means that heat was exchanged between the coolant and air such that the air only rose 10°F. The closer the temperatures are to each other to begin with, the less of a heat transfer affect they can exert on each other.

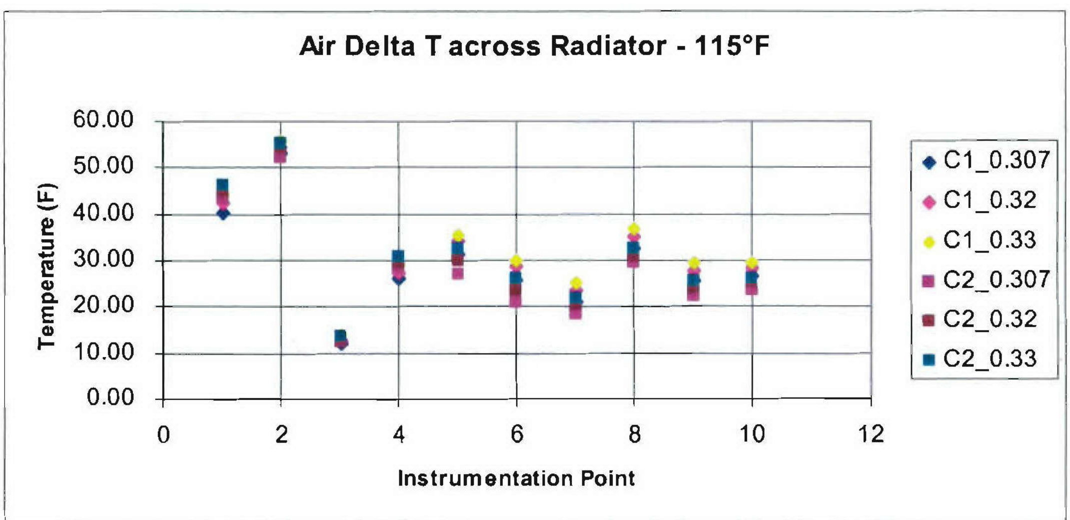


**Figure 23 – Air Temperature Difference (Air Delta T) Mapping Across Radiator**

## 8.5 EXHAUST GAS RECIRCULATION

Also impacting the ability of the vehicle to meet its cooling requirement is that the path that the exhaust gas takes to leave the vehicle contains leaks. These leaks are allowing the exhaust gas to be recirculated into the radiator. When looking at Figure 24 notice the black areas around the exhaust. This is soot.

**Figure 24 – Exhaust Gases Blow by the Exhaust Seal and Recirculate under Armor**

The seal in the top exhaust grille (Figure 25) is intended to bridge the gap between the end of the exhaust pipe and the exhaust grille itself, to keep the gas from being sucked back into the engine compartment. However, from the pictures, it is evident that this isn't working as well as planned. Power washing of the radiator revealed that there was a lot of oil and soot that had lodged itself in the radiator fins. The heat transfer capability of the radiator is reduced when the metal tubes become coated with any other substance.

The soot, as mentioned, was from the exhaust gas recirculation. The oil comes from the breathers on top of the engine. Essentially these are vents to regulate pressure in the engine and oil laced vapors can readily escape from them. There is no way to remedy this oil fouling condition based on this given current cooling configuration that has the engine placed before the radiator in the cooling air flow path.

There is a set of gaskets in place around the radiator to prevent any exhaust gases from entering back into the engine compartment but the sealing of these gaskets isn't sufficient enough to prevent gases from flowing back from the area that is visible in

Figure 26 into the engine compartment and then immediately back through the radiator.

Another side effect of the exhaust gases re-entering the engine compartment is that it is causing increased wear on the radiator tubing and radiator cap. Take note of all the soot around the hoses and cap in Figure 26. The effect of these gases is hardening of rubber components. Several times during the testing program, coolant levels were found to be low, but no obvious leak could be found. The leak was finally traced to the radiator cap area. However, the leakage was so slight and minimal that the coolant was being evaporated off immediately as it leaked out, which was why it was difficult to find. While only a small and slow leak, over time this could pose a cooling problem with a vehicle. Rubber hoses and caps near the right side of the radiator should be routinely checked and replaced if found to be hardening.

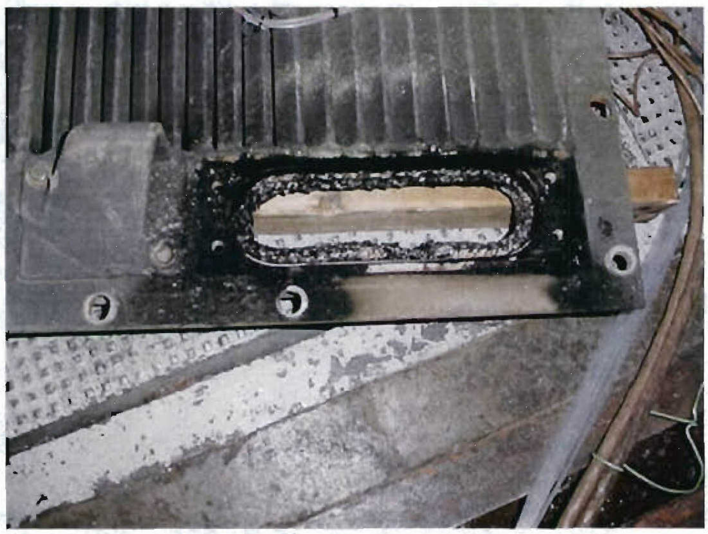

**Figure 25 – Exhaust Grille with Inset Exhaust Gas Seal**

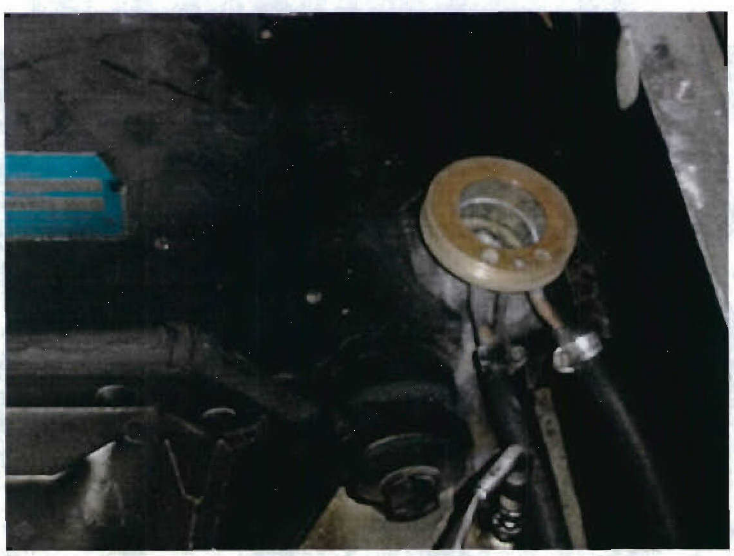

**Figure 26 – Evidence of Exhaust Gas Recirculation on Radiator Hoses and Cap**

## 9.0 OPTIONS TO IMPROVE VEHICLE COOLING

### 9.1 SLANTED RADIATOR CHANGE

In the current power pack configuration, the radiator and the fans that push cooling air through the radiator are oriented parallel to each other and are only a few inches apart (Figure 27). This means of packaging these two items is very effective for a constrained area since the volume required is minimized. However, it tends to adversely impact the efficiency of the radiator to reject heat.

The heat rejection capability of the radiator is reduced under this packaging configuration because the fans are so close to the radiator that the air, upon exiting the fans, does not have enough space to distribute evenly over the surface of the radiator and instead passes through the radiator in a circular pattern not much larger than the fan diameter. Sections of the radiator not directly behind the cooling fans get a lower percentage of airflow, therefore providing lower heat transfer than these sections are capable of. This uneven distribution of airflow over the radiator reduces its efficiency.

A method to improve this situation, which is routinely employed by other military vehicles, is to slant the radiator such that the distance between the fans that the surface of the radiator is increased. Figure 28 shows the difference between a normal installation, shown in Figure 28A, and the proposed installation utilizing a slanted radiator, shown in Figure 28B. In Figure 28, the space now existing between the radiator and the fans allows the air to more widely disperse once it leaves the fans thus providing more consistent airflow across the entirety of the radiator. This maximizes the efficiency of the existing radiator.

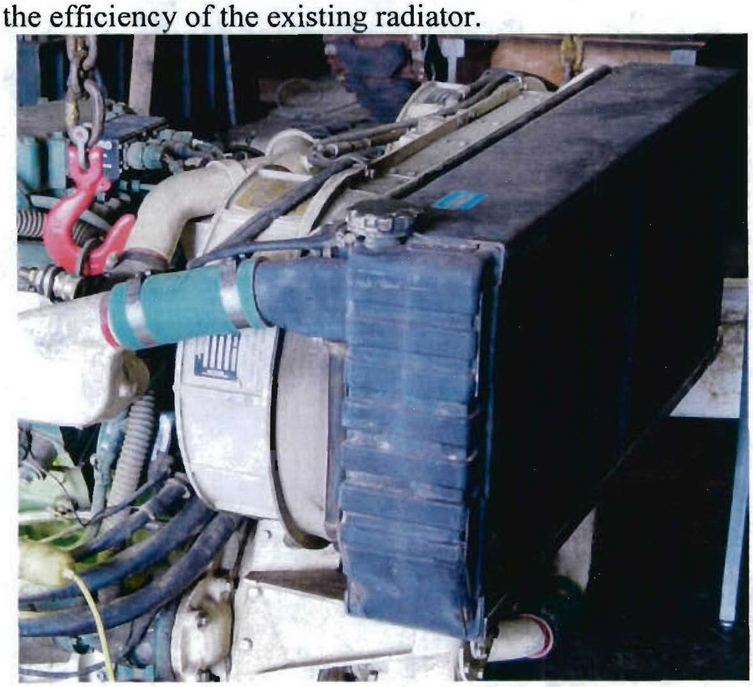

**Figure 27 – Radiator and Fans are Just Inches from Each Other**

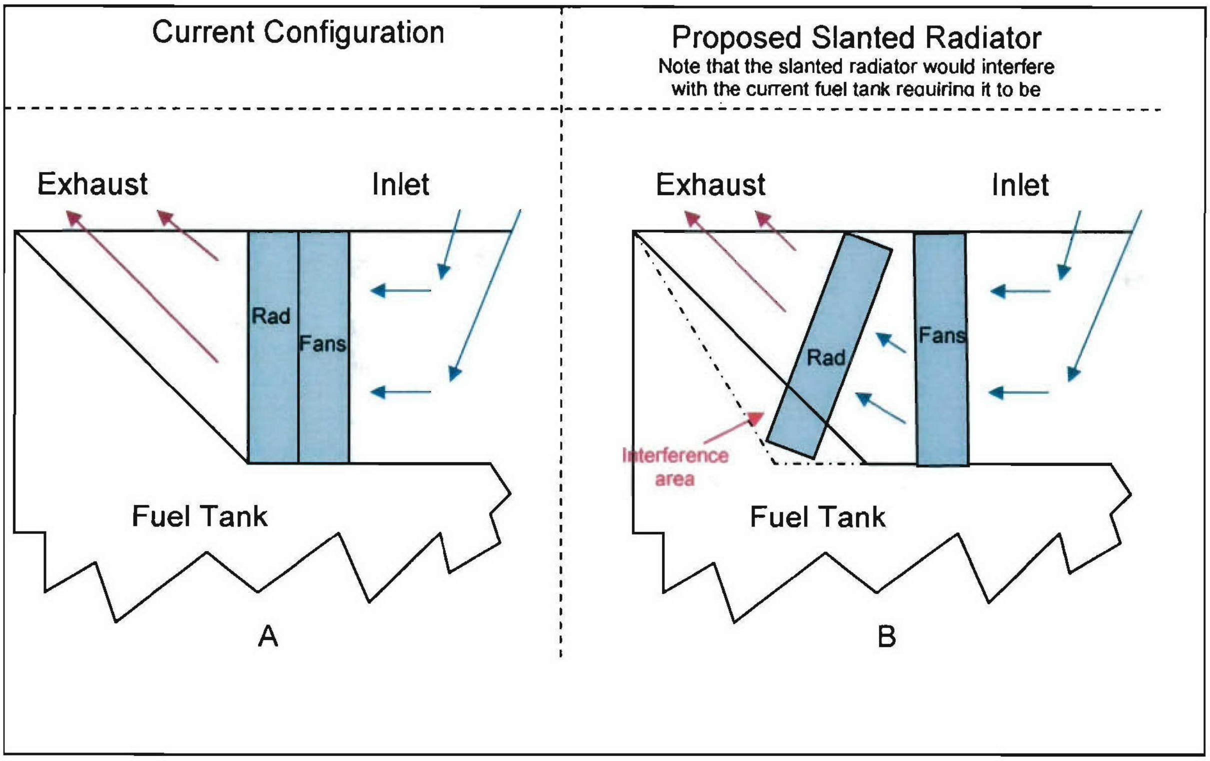


**Figure 28 – Installation of a Slanted Radiator in an M109A6**

The slanted radiator, while maximizing heat transfer efficiency, would require a modification to the vehicle fuel tank. As shown in Figure 28, the fuel tank sits under, and beside, the air's exhaust path out of the vehicle. Slanting the radiator will pull the bottom end of it out and into the area the fuel tank currently occupies. This is unavoidable because the radiator cannot be shrunk and still provide adequate performance. The fuel tank (and the shroud the separates it from the airflow stream) would need to be redesigned so that the profile will be more like the dashed line in Figure 28B.

## 9.2 WATER PUMP UPGRADE

A water pump from a DDC 8V92 engine was used on the 8V71T engine for a no-load flow test and run with the power pack out of vehicle. Physically, it fit well and there were no interference problems. Some revisions to the pump housing are necessary to adapt to the engine. Functionally, it delivered coolant flow of about 10% higher than the 8V71T water pump. This will not make a significant difference in cooling, but every little bit helps so future upgrades should seriously consider the use of the 8V92 water pump. In addition to providing higher coolant flow, it opens up the possibility to reduce the number of unique parts in the Army's inventory system. Typically, reducing the number of unique parts in inventory leads to cost savings.

## 9.3 REDUCE SIGNATURE OF VEHICLE –POSSIBLE AID IN COOLING

During the testing of the vehicle we contacted the survivability group at TARDEC and had a series of informal discussion on ways to both increase the survivability of the vehicle and increase the cooling capability of the vehicle.

When the air has to make twists and turns to get into and out of the vehicle, efficiency, power and cooling capability is lost. In looking at the Paladin, there are a couple of areas where redesigning the flow path may provide some additional benefit.

The engine exhaust system currently exits the top on the vehicle. The pipe, prior to exiting the top of the vehicle, makes a 90° turn from heading directly toward the side of the vehicle. This turn creates backpressure and will results in some margin of power loss. It would be ideal to exhaust directly out the side of the vehicle. Our concern with this method was that hot exhaust out the side may pose a signature threat due to increased temperature on the side armor of the vehicle. The opinion we obtained from the survivability folks was that a side exhaust should not alter the survivability of the vehicle. Therefore, exploration of a side engine exhaust should be considered in a future upgrade program.

For reason similar to those for the engine exhaust, the exhaust location for the cooling air should be considered being relocated to the side of the vehicle also. This would provide a more direct path for the air. For both of these options, a side exhaust will reduce the amount of hot gas and air that is being re-circulated into the cooling stream do to the closeness of the inlet and exhaust ports on the vehicle. Obviously, both of these upgrade options are not trivial in nature as they will require new armored side grilles which may alter the current ballistic protection characteristics of the vehicle.

In collaboration with the survivability folks, we have devised a potential method to both reduce the signature of the vehicle as well as to increase the flow of air inside the engine compartment. It should be noted that this solution is novel in nature and has not been attempted, to our knowledge, on a military vehicle before. It is based largely on an idea that came about as we were trying to reach agreement on a mutually acceptable cooling scheme for the Future Tactical Truck System that would satisfy both the needs of both the survivability and mobility groups.

The idea is to cut slots into the engine exhaust pipe such that the venturi effect is leveraged to draw hot engine compartment air into the engine exhaust pipe and out of the vehicle (see Figure 29). The purpose is to increase the circulation of air within the engine compartment thus aiding the cooling capability of the vehicle. The slots should create a negative pressure differential directly downstream of the opening which will work to draw in engine compartment air where it will then get caught in the exhaust flow stream. Nothing is free in this world and there is a cost associated with this. That is that the exhaust pipe diameter would need to get gradually larger as it approached the vehicle exit to allow for the additional volume of air that is being sucked into the pipe from the engine compartment.

The benefit for the survivability folks is that the engine compartment's "hot" air is actually much cooler than the engine exhaust air. Therefore, the engine exhaust air is effectively being cooled prior to exiting the vehicle. The benefit to the mobility folks is that air circulation is increase in the engine compartment, helping to combat dead zones and expel hot air. It is likely that this setup would aid in signature reduction by cooling the exhaust gases, but the quantity of air removed from the engine compartment may not be large enough with respect to the shear volume of the engine compartment air to make any noticeable difference on the cooling side.

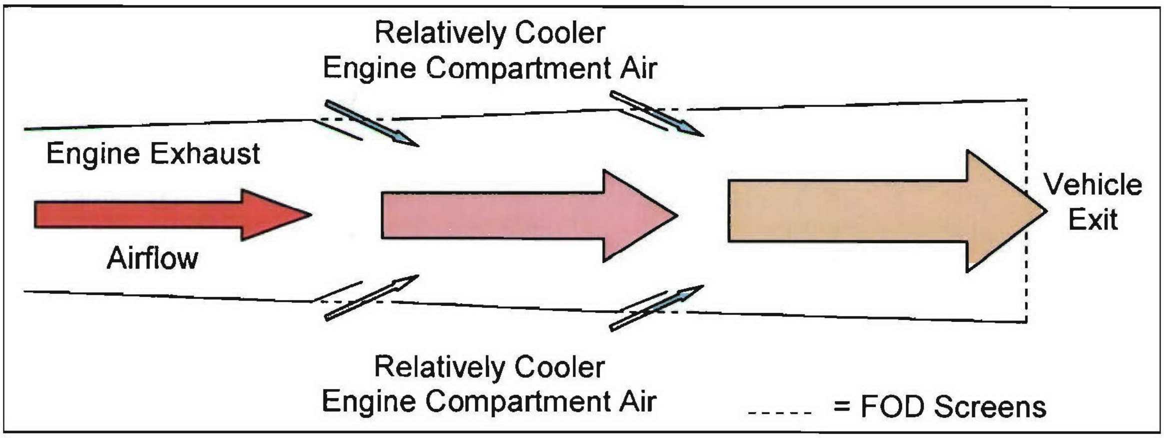


**Figure 29 – Conceptual View of Slotted Exhaust Duct**

## 9.4 FAN DRIVE CHANGE

During this test it has been proven that the amount of cooling airflow is important to the vehicle being able to achieve proper cooling. Currently, the vehicle cooling fans are designed and built such that they are connected to the engine and are driven in a ratio directly proportional to how fast the engine is running. This means that a lot of cooling air is flowing across the radiator when the engine is running at a fast speed. This doesn't necessarily mean when it's running at top speed, it could mean that the transmission is in a condition just prior to up shifting gears. The high tractive effort to weight points do not necessarily occur at the top engine speeds, rather they occur several hundred RPM lower. With a mechanical system there is no way to leverage the additional output potential of the fans under at this condition.

The high TE/WT points almost never occur at high engine speeds because the engine is less efficient at generating torque at high RPM's. Rather they occur several hundred RPM lower, as is the case with the Paladin. With a mechanical system there is no way to leverage the additional output potential of the fans while achieving high TE/WT's.

Systems that can be considered for future upgrades include hydraulic and electrically driven fan drives. These systems would allow the fan to spin fast and draw large amounts of air when cooling demands are high and spin slower and conserve power when cooling demands are light. This could be a function of not only power pack operating condition, but also of ambient conditions. Recalling the previous discussion of Delta T, if a vehicle is operating in a cold climate, the Delta T, the temperature difference, will be much larger between cooling air and radiator coolant. This will make the cooling system very effective even with a lower amount of airflow, corresponding to a slower spinning fan. In the current mechanical configuration, the cooling fans spin just as fast in the artic winter climate as they do in the hot desert.

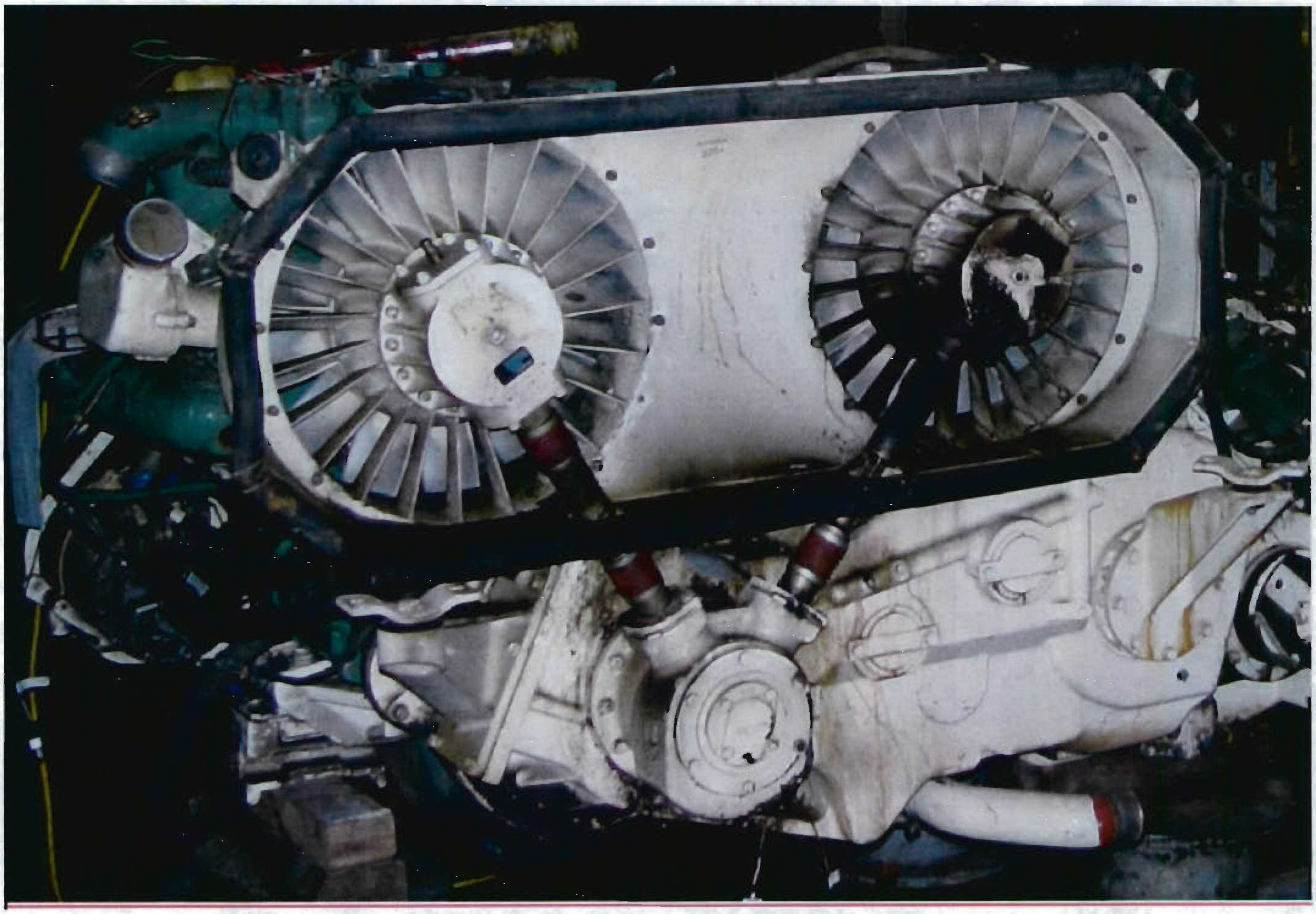

**Figure 30 – 8V-71T Power Pack Showing Mechanical Dual Fan Drive**

## 10.0 ACKNOWLEDGEMENTS

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Roger Hewlett – Engine Support
Rick Agnetti – Parts Acquisition
Matt Brolsma – Test Operations and Data Analysis

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## 11.0 REFERENCES

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# APPENDIX A

*RAW REDUCED TEST DATA*

*For*

*Full Load Cooling Tests*

## Glossary of Data Acquisition System Nomenclature

A Cell Mate Data Acquisition System was used to record data for all testing done. Due to limitation in the Cell Mate, abbreviated nomenclature was used to describe each channel of data that was being taken. To clarify what the nomenclature is, the following table has been devised. It contains the complete description of the data the channel was recording as well as the units it was being recorded in.

| Cell Mate Verbage | Units | Description |
|---|---|---|
| FUEL USAGE | lbs/hr | Fuel Usage |
| fuel counts | unitless | Number of Current Weigh Cycle per Beaker |
| ENGINE SPEED | RPM | Engine Speed |
| NORTH TORQUE | ft-lbs/10 | North Dynamometer Torque Output divided by 10 |
| SOUTH TORQUE | ft-lbs/10 | South Dynamometer Torque Output divided by 10 |
| TOTAL TORQUE | ft-lbs | Combined Dynamometer Torque, calculated |
| NORTH SPEED | RPM | North Dynamometer Speed Reading |
| SOUTH SPEED | RPM | South Dynamometer Speed Reading |
| NORTH HP | HP | North Dynamometer Horsepower |
| SOUTH HP | HP | South Dynamometer Horsepower |
| TOTAL SHP | HP | Total Sprocket Horsepower |
| pBARO | "HG | Barometric Pressure |
| GEN OIL | Hz | Generator Oil Flow |
| ENG OIL FLOW | gpm | Engine Oil Flow Rate |
| CLNT FLOW | gpm | Coolant Flow Rate |
| SURGE FLOW | Gpm | Coolant Flow to/through Surge Tank |
| CELL DEP H2O | "H2O | Pressure in Test Cell |
| AIR B4 FILTER | "H2O | Air Pressure Before Engine Air Filter |
| AIR B4 TURBO f | °F | Air Temperature Before Turbocharger |
| AIR B4 TURBO p | PSI | Air Pressure Before Turbocharger |
| AIR AFT TURBO f | °F | Air Temperature After Turbocharger |
| AIR BOX TEMP | °F | Temp in Area Around Cylinder Inlet Ports |
| AIR BOX | PSI | Pressure in Area Around Cylinder Inlet Ports |
| EX B4 TURBO | PSI | Exhaust Pressure Before Turbocharger |
| EX AFT TURBO | "H2O | Exhaust Pressure After Turbocharger |
| ENG OIL SUMP | °F | Engine Oil Sump Temperature |
| OIL TEMP GALLERY | °F | Engine Oil Gallery Temperature |
| OIL GALLERY | psi | Engine Oil Gallery Pressure |
| OIL B4 ENG CLR | °F | Engine Oil Temp Before Engine Oil Cooler |
| TRANS OIL SUMP | °F | Transmission Oil Sump Temperature |
| TRANS MAIN | psi | Transmission Oil Pressure |
| OIL B4 TRAN CLR | °F | Oil Temp Before Transmission Oil Cooler |
| OIL AFT TRAN CLR | °F | Oil Temp After Transmission Oil Cooler |
| FUEL SUP | °F | Fuel Supply Temperature |
| FUEL RET | °F | Fuel Return Temperature |
| FUEL SUP | psi | Fuel Pressure in Supply Line |
| FUEL AFT PUMP | psi | Fuel Pressure After Fuel Pump |

| | | |
|---|---|---|
| FUEL RET | psi | Fuel Pressure in Return Line |
| CLNT B4 RAD | psi | Coolant Pressure Before Radiator |
| CLNT AFT RAD | psi | Coolant Pressure After Radiator |
| CLNT AFT T CLR | °F | Coolant Temperature After Trans Oil Cooler |
| CLNT B4 AFT CLR | °F | Coolant Temperature Before Aftercooler |
| CLNT AFT AFT CLR | °F | Coolant Temperature After Aftercooler |
| CLNT B4 PUMP | psi | Coolant Pressure Before Water Pump |
| CELL AMB T/L | °F | Test Cell Ambient Temperature |
| CELL AMB B/L | °F | Test Cell Ambient Temperature |
| CELL AMB T/R | °F | Test Cell Ambient Temperature |
| CELL AMB B/R | °F | Test Cell Ambient Temperature |
| AIR B4 INLET 1 | °F | Air Temperature Before Inlet Grille |
| AIR B4 INLET 2 | °F | Air Temperature Before Inlet Grille |
| AIR B4 INLET 3 | °F | Air Temperature Before Inlet Grille |
| AIR B4 INLET 4 | °F | Air Temperature Before Inlet Grille |
| AIR B4 INLET 5 | °F | Air Temperature Before Inlet Grille |
| AIR B4 INLET 6 | °F | Air Temperature Before Inlet Grille |
| AIR B4 INLET 7 | °F | Air Temperature Before Inlet Grille |
| AIR AFT INLET 1 | °F | Air Temperature After Inlet Grille |
| AIR AFT INLET 2 | °F | Air Temperature After Inlet Grille |
| AIR AFT INLET 3 | °F | Air Temperature After Inlet Grille |
| AIR AFT INLET 4 | °F | Air Temperature After Inlet Grille |
| AIR AFT INLET 5 | °F | Air Temperature After Inlet Grille |
| AIR AFT INLET 6 | °F | Air Temperature After Inlet Grille |
| AIR AFT INLET 7 | °F | Air Temperature After Inlet Grille |
| AIR >FAN L/1 | °F | Air Temperature Before Left Cooling Fan |
| AIR >FAN L/2 | °F | Air Temperature Before Left Cooling Fan |
| AIR >FAN L/3 | °F | Air Temperature Before Left Cooling Fan |
| AIR >FAN L/4 | °F | Air Temperature Before Left Cooling Fan |
| AIR >FAN R/1 | °F | Air Temperature Before Right Cooling Fan |
| AIR >FAN R/2 | °F | Air Temperature Before Right Cooling Fan |
| AIR >FAN R/3 | °F | Air Temperature Before Right Cooling Fan |
| AIR >FAN R/4 | °F | Air Temperature Before Right Cooling Fan |
| AIR B4 RAD 1 | °F | Temperature of Air Before Radiator |
| AIR B4 RAD 2 | °F | Temperature of Air Before Radiator |
| AIR B4 RAD 3 | °F | Temperature of Air Before Radiator |
| AIR B4 RAD 4 | °F | Temperature of Air Before Radiator |
| AIR B4 RAD 5 | °F | Temperature of Air Before Radiator |
| AIR B4 RAD 6 | °F | Temperature of Air Before Radiator |
| AIR B4 RAD 7 | °F | Temperature of Air Before Radiator |
| AIR B4 RAD 8 | °F | Temperature of Air Before Radiator |
| AIR B4 RAD 9 | °F | Temperature of Air Before Radiator |
| AIR B4 RAD 10 | °F | Temperature of Air Before Radiator |
| AIR AFT RAD 1 | °F | Temperature of Air After Radiator |
| AIR AFT RAD 2 | °F | Temperature of Air After Radiator |
| AIR AFT RAD 3 | °F | Temperature of Air After Radiator |

| | | |
|---|---|---|
| AIR AFT RAD 4 | °F | Temperature of Air After Radiator |
| AIR AFT RAD 5 | °F | Temperature of Air After Radiator |
| AIR AFT RAD 6 | °F | Temperature of Air After Radiator |
| AIR AFT RAD 7 | °F | Temperature of Air After Radiator |
| AIR AFT RAD 8 | °F | Temperature of Air After Radiator |
| AIR AFT RAD 9 | °F | Temperature of Air After Radiator |
| AIR AFT RAD 10 | °F | Temperature of Air After Radiator |
| AIR B4 EX GR 1 | "H2O | Air Pressure Before Exhaust Grille |
| AIR B4 EX GR 2 | "H2O | Air Pressure Before Exhaust Grille |
| AIR B4 EX GR 3 | "H2O | Air Pressure Before Exhaust Grille |
| AIR B4 EX GR 4 | "H2O | Air Pressure Before Exhaust Grille |
| AIR B4 EX GR 5 | "H2O | Air Pressure Before Exhaust Grille |
| AIR B4 EX GR 6 | "H2O | Air Pressure Before Exhaust Grille |
| AIR AFT EX GR 1 | "H2O | Air Pressure After Exhaust Grille |
| AIR AFT EX GR 2 | "H2O | Air Pressure After Exhaust Grille |
| AIR AFT EX GR 3 | "H2O | Air Pressure After Exhaust Grille |
| AIR AFT EX GR 4 | "H2O | Air Pressure After Exhaust Grille |
| AIR AFT EX GR 5 | "H2O | Air Pressure After Exhaust Grille |
| AIR AFT EX GR 6 | "H2O | Air Pressure After Exhaust Grille |
| AIR B4 IN GR p1 | "H2O | Air Pressure Before Vehicle Inlet Grille |
| AIR B4 IN GR p2 | "H2O | Air Pressure Before Vehicle Inlet Grille |
| AIR B4 IN GR p3 | "H2O | Air Pressure Before Vehicle Inlet Grille |
| AIR B4 IN GR p4 | "H2O | Air Pressure Before Vehicle Inlet Grille |
| AIR B4 IN GR p5 | "H2O | Air Pressure Before Vehicle Inlet Grille |
| AIR B4 IN GR p6 | "H2O | Air Pressure Before Vehicle Inlet Grille |
| AIR B4 IN GR p7 | "H2O | Air Pressure Before Vehicle Inlet Grille |
| AIR AFT IN GR p1 | "H2O | Air Pressure After Vehicle Inlet Grille |
| AIR AFT IN GR p2 | "H2O | Air Pressure After Vehicle Inlet Grille |
| AIR AFT IN GR p3 | "H2O | Air Pressure After Vehicle Inlet Grille |
| AIR AFT IN GR p4 | "H2O | Air Pressure After Vehicle Inlet Grille |
| AIR AFT IN GR p5 | "H2O | Air Pressure After Vehicle Inlet Grille |
| AIR AFT IN GR p6 | "H2O | Air Pressure After Vehicle Inlet Grille |
| AIR AFT IN GR p7 | "H2O | Air Pressure After Vehicle Inlet Grille |
| AIR AFT IN TP1 | "H2O | Air after inlet grille total pressure |
| AIR AFT IN TP2 | "H2O | Air after inlet grille total pressure |
| AIR AFT IN TP3 | "H2O | Air after inlet grille total pressure |
| AIR AFT IN TP4 | "H2O | Air after inlet grille total pressure |
| AIR AFT IN TP5 | "H2O | Air after inlet grille total pressure |
| AIR AFT IN TP6 | "H2O | Air after inlet grille total pressure |
| AIR AFT IN TP7 | "H2O | Air after inlet grille total pressure |
| AIR B4 FAN L/p1 | "H2O | Air Pressure Before Left Fan |
| AIR B4 FAN L/p2 | "H2O | Air Pressure Before Left Fan |
| AIR B4 FAN L/p3 | "H2O | Air Pressure Before Left Fan |
| AIR B4 FAN L/p4 | "H2O | Air Pressure Before Left Fan |
| AIR B4 FAN R/p1 | "H2O | Air Pressure Before Right Fan |
| AIR B4 FAN R/p2 | "H2O | Air Pressure Before Right Fan |

| | | |
|---|---|---|
| AIR B4 FAN R/p3 | "H2O | Air Pressure Before Right Fan |
| AIR B4 FAN R/p4 | "H2O | Air Pressure Before Right Fan |
| AIR B4 FAN LTP1 | "H2O | Air Pressure Before Left Fan, Total Pressure |
| AIR B4 FAN LTP2 | "H2O | Air Pressure Before Left Fan, Total Pressure |
| AIR B4 FAN LTP3 | "H2O | Air Pressure Before Left Fan, Total Pressure |
| AIR B4 FAN LTP4 | "H2O | Air Pressure Before Left Fan, Total Pressure |
| AIR B4 FAN RTP1 | "H2O | Air Pressure Before Right Fan, Total Pressure |
| AIR B4 FAN RTP2 | "H2O | Air Pressure Before Right Fan, Total Pressure |
| AIR B4 FAN RTP3 | "H2O | Air Pressure Before Right Fan, Total Pressure |
| AIR B4 FAN RTP4 | "H2O | Air Pressure Before Right Fan, Total Pressure |
| DUCER RACK | °F | Temperature at Transducer Rack |
| SURGE TANK | psi | Surge Tank Pressure |
| | | |
| Clnt>Rad 1 | °F | Coolant Temp Into Radiator |
| Clnt>Rad 2 | °F | Coolant Temp Into Radiator |
| ClntRad> 1 | °F | Coolant Temp Out of Radiator |
| ClntRad> 2 | °F | Coolant Temp Out of Radiator |
| ClntRad> 3 | °F | Coolant Temp Out of Radiator |
| ClntRad> average | °F | Average Coolant Temp Out of Radiator |
| Clnt>Pmp 1 | °F | Coolant Temp Into Water Pump |
| Clnt>Pmp 2 | °F | Coolant Temp Into Water Pump |
| Clnt>Pmp 3 | °F | Coolant Temp Into Water Pump |
| Clnt>Pmp 4 | °F | Coolant Temp Into Water Pump |
| Ex>Turbo | °F | Exhaust Temp Before Turbocharger |
| ExTurbo> | °F | Exhaust Temp After Turbocharger |
| Oil FD L | °F | Final Drive Oil Temperature |
| Oil FD R | °F | Final Drive Oil Temperature |
| AirComp> | psi | Air Pressure after Compressor |
| Air>Rad 1 | "H2O | Air Pressure Before Radiator |
| Air>Rad 2 | "H2O | Air Pressure Before Radiator |
| Air>Rad 3 | "H2O | Air Pressure Before Radiator |
| Air>Rad 4 | "H2O | Air Pressure Before Radiator |
| Air>Rad 5 | "H2O | Air Pressure Before Radiator |
| Air>Rad 6 | "H2O | Air Pressure Before Radiator |
| Air>Rad 7 | "H2O | Air Pressure Before Radiator |
| Air>Rad 8 | "H2O | Air Pressure Before Radiator |
| Air>Rad 9 | "H2O | Air Pressure Before Radiator |
| Air>Rad 10 | "H2O | Air Pressure Before Radiator |
| AirRad> 1 | "H2O | Air Pressure After Radiator |
| AirRad> 2 | "H2O | Air Pressure After Radiator |
| AirRad> 3 | "H2O | Air Pressure After Radiator |
| AirRad> 4 | "H2O | Air Pressure After Radiator |
| AirRad> 5 | "H2O | Air Pressure After Radiator |
| AirRad> 6 | "H2O | Air Pressure After Radiator |
| AirRad> 7 | "H2O | Air Pressure After Radiator |
| AirRad> 8 | "H2O | Air Pressure After Radiator |

| | | |
|---|---|---|
| AirRad> 9 | "H2O | Air Pressure After Radiator |
| AirRad> 10 | "H2O | Air Pressure After Radiator |
| AirRad>TP1 | "H2O | Air Pressure After Radiator, Total Pressure |
| AirRad>TP2 | "H2O | Air Pressure After Radiator, Total Pressure |
| AirRad>TP3 | "H2O | Air Pressure After Radiator, Total Pressure |
| AirRad>TP4 | "H2O | Air Pressure After Radiator, Total Pressure |
| AirRad>TP5 | "H2O | Air Pressure After Radiator, Total Pressure |
| AirRad>TP6 | "H2O | Air Pressure After Radiator, Total Pressure |
| AirRad>TP7 | "H2O | Air Pressure After Radiator, Total Pressure |
| AirRad>TP8 | "H2O | Air Pressure After Radiator, Total Pressure |
| AirRad>TP9 | "H2O | Air Pressure After Radiator, Total Pressure |
| AirRad>TP10 | "H2O | Air Pressure After Radiator, Total Pressure |
| Air>Exh Grl 1 | "H2O | Pressure Before Exhaust Grille |
| Air>Exh Grl 2 | "H2O | Pressure Before Exhaust Grille |
| Air>Exh Grl 3 | "H2O | Pressure Before Exhaust Grille |
| Air>Exh Grl 4 | "H2O | Pressure Before Exhaust Grille |
| Air>Exh Grl 5 | "H2O | Pressure Before Exhaust Grille |
| Air>Exh Grl 6 | "H2O | Pressure Before Exhaust Grille |
| Air>Exh Grl TP1 | "H2O | Air Pressure Before Exhaust Grille, Total Pressure |
| Air>Exh Grl TP2 | "H2O | Air Pressure Before Exhaust Grille, Total Pressure |
| Air>Exh Grl TP3 | "H2O | Air Pressure Before Exhaust Grille, Total Pressure |
| Air>Exh Grl TP4 | "H2O | Air Pressure Before Exhaust Grille, Total Pressure |
| Air>Exh Grl TP5 | "H2O | Air Pressure Before Exhaust Grille, Total Pressure |
| Air>Exh Grl TP6 | "H2O | Air Pressure Before Exhaust Grille, Total Pressure |
| AirExh GRL> 1 | "H2O | Pressure After Exhaust Grille |
| AirExh GRL> 2 | "H2O | Pressure After Exhaust Grille |
| AirExh GRL> 3 | "H2O | Pressure After Exhaust Grille |
| AirExh GRL> 4 | "H2O | Pressure After Exhaust Grille |
| AirExh GRL> 5 | "H2O | Pressure After Exhaust Grille |
| AirExh GRL> 6 | "H2O | Pressure After Exhaust Grille |

| TE/WT at Temp | FUEL usage | fuel counts | ENGINE SPEED | NORTH TORQUE | SOUTH TORQUE | TOTAL TORQUE | NORTH SPEED | SOUTH SPEED | NORTH HP | SOUTH HP | TOTAL SHP | pBARO HG | GEN OIL DCT-HZ | ENG OIL FLOW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.35 | 129.01 | 0.73 | 1667.23 | 895.41 | 885.55 | 1780.95 | 81.84 | 81 81 | 139.52 | 137.94 | 277.46 | 29.37 | 458.91 | 10.63 |
| 0 45 | 132.50 | 0.68 | 1729.00 | 1157.45 | 1159.50 | 2316.95 | 54.65 | 54.63 | 120.43 | 120.61 | 241.04 | 29.35 | 468.41 | 11.06 |
| 0.50 | 129.29 | 0.76 | 1671.24 | 1298.10 | 1297.24 | 2595.33 | 47.09 | 47.07 | 116.39 | 116.25 | 232.64 | 29.35 | 464.19 | 10.88 |
| 0.55 | 127.43 | 0 77 | 1650.41 | 1428 45 | 1428.45 | 2856.91 | 40.88 | 40.87 | 111.19 | 111.15 | 222.34 | 29.34 | 460.95 | 10.80 |
| 0.60 | 126.16 | 0.76 | 1631.00 | 1543.05 | 1534 71 | 3077.76 | 36.14 | 36 16 | 106.19 | 105.67 | 211.85 | 29 33 | 459.24 | 10.77 |
| **105°F** | | | | | | | | | | | | | | |
| 0.26 | 161 28 | 0.63 | 2343.00 | 696.29 | 677.67 | 1373.96 | 114.95 | 114.93 | 152.39 | 148.28 | 300.68 | 29.02 | 529.54 | 12.73 |
| 0.31 | 144.59 | 0.70 | 1985.05 | 814.70 | 803.65 | 1618.35 | 97.53 | 97.54 | 151.29 | 149.25 | 300.54 | 29.02 | 490.00 | 11.56 |
| 0.32 | 135.17 | 0.68 | 1807.32 | 849.09 | 844.77 | 1693.86 | 88.79 | 88.81 | 143.54 | 142.85 | 286.39 | 29.03 | 472.14 | 10.97 |
| 0.33 | 129.50 | 0.76 | 1709.19 | 868.43 | 860.76 | 1729.19 | 83.84 | 83.80 | 138.63 | 137.34 | 275.96 | 29.03 | 462.52 | 10.59 |
| 0.35 | 136.13 | 0.55 | 1844.05 | 933.55 | 885.73 | 1819.27 | 68.80 | 68.83 | 122.30 | 116.08 | 238.38 | 29.06 | 478.64 | 11.24 |
| 0.40 | 132.30 | 0.62 | 1768.00 | 1043.48 | 1061.81 | 2105.29 | 60.11 | 60.11 | 119.43 | 121.53 | 240.97 | 29.44 | 470.67 | 11.36 |
| 0.45 | 128.75 | 0.67 | 1707.95 | 1166.48 | 1181.48 | 2347.95 | 52.26 | 52.26 | 116.07 | 117 56 | 233.64 | 29.44 | 464.33 | 11.18 |
| 0.50 | 126.15 | 0.73 | 1661.82 | 1299.77 | 1306.09 | 2605.86 | 45.62 | 45.62 | 112.89 | 113.45 | 226.35 | 29.44 | 459.59 | 11.02 |
| 0.55 | 124.29 | 0.55 | 1631.23 | 1437.59 | 1433.14 | 2870.73 | 39.34 | 39.35 | 107.68 | 107 36 | 215.04 | 29.44 | 456.77 | 10.98 |
| 0.60 | 122.93 | 0.68 | 1611.00 | 1565.23 | 1546.23 | 3111.45 | 34 31 | 34.30 | 102.26 | 100.98 | 203.24 | 29.44 | 454.86 | 10.92 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 142 19 | 0.64 | 1984.59 | 802.55 | 784.73 | 1587.27 | 96.51 | 96.49 | 147.48 | 144.16 | 291.64 | 28.80 | 494.73 | 12.24 |
| 0.32 | 132.67 | 0.77 | 1783.91 | 824.18 | 829.82 | 1654.00 | 87.55 | 87.52 | 137.39 | 138.28 | 275.67 | 28.78 | 477.18 | 11.57 |
| 0.33 | 124.39 | 0.61 | 1630.26 | 853.00 | 853.17 | 1706.17 | 80.11 | 80.13 | 130.11 | 130 17 | 260.28 | 28.77 | 460.48 | 11 01 |
| ***Configuration 2*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.294 | 159.04 | 0.50 | 2212.86 | 765.27 | 756.45 | 1521.73 | 108.56 | 108.56 | 158.19 | 156.36 | 314.55 | 29.48 | 513.50 | 12.43 |
| 0.33 | 141.20 | 0.52 | 1876.95 | 865.76 | 845.57 | 1711.33 | 92.12 | 92.14 | 151.86 | 148.34 | 300.20 | 29.45 | 476.33 | 11 14 |
| 0.35 | 128.91 | 0.83 | 1651.13 | 917.61 | 897.61 | 1815.22 | 81.27 | 81.33 | 141.99 | 138.99 | 280.98 | 29.43 | 451.30 | 10.33 |
| 0.35 | 129.60 | 0.68 | 1671.00 | 948.95 | 866.45 | 1815.41 | 82.08 | 82.06 | 148.30 | 135.38 | 283.68 | 29.10 | 453.64 | 10.61 |
| 0.40 | 131.96 | 0.61 | 1728.48 | 1046.09 | 1031.87 | 2077.96 | 61.94 | 61.94 | 123.38 | 121.70 | 245.07 | 29.10 | 462.52 | 10.98 |
| 0.45 | 127.48 | 0.73 | 1643.45 | 1181.09 | 1156.41 | 2337.50 | 53.99 | 54.03 | 121.41 | 118.97 | 240.38 | 29.09 | 453.91 | 10.66 |
| 0.50 | 122.98 | 0.85 | 1572.00 | 1331.30 | 1310.55 | 2641.85 | 44.87 | 44.91 | 113.72 | 112.06 | 225.79 | 29.09 | 445 75 | 10.40 |
| 0.55 | 120.08 | 0.68 | 1531.32 | 1443.05 | 1445.45 | 2888.50 | 38.54 | 38.52 | 105.88 | 106.01 | 211.89 | 29.10 | 441.41 | 10.27 |
| 0.60 | 117.93 | 0.86 | 1493.00 | 1568.00 | 1580.00 | 3148.00 | 32.89 | 32.89 | 98.19 | 98.94 | 197.14 | 29.11 | 438.29 | 10.19 |
| **105°F** | | | | | | | | | | | | | | |
| 0.307 | 152.94 | 0.52 | 2103.19 | 792.00 | 786.05 | 1578.05 | 103.22 | 103.23 | 155.66 | 154.50 | 310.15 | 29.73 | 502.90 | 12.18 |
| 0.33 | 137.31 | 0.52 | 1814.00 | 860.00 | 850.86 | 1710.86 | 89.20 | 89.20 | 146.06 | 144.51 | 290.57 | 29.73 | 472.14 | 11.22 |
| 0.40 | 130.06 | 0.87 | 1704.74 | 1080.22 | 1005.04 | 2085.26 | 60.60 | 60.59 | 124.64 | 115.95 | 240.59 | 29.71 | 463.74 | 10.88 |
| 0.45 | 124.93 | 0.74 | 1611.00 | 1157.13 | 1198.17 | 2355.30 | 51.98 | 51.97 | 114.53 | 118.57 | 233.10 | 29.71 | 453.61 | 10.61 |
| 0.50 | 122.08 | 0.74 | 1570.79 | 1305.47 | 1296.95 | 2602.42 | 45.11 | 45.11 | 112.13 | 111.38 | 223.51 | 29.71 | 447.79 | 10.42 |
| 0.55 | 119.35 | 0.86 | 1525.38 | 1431.38 | 1435.71 | 2867 10 | 38.70 | 38.69 | 105.46 | 105.76 | 211.22 | 29.71 | 443.38 | 10.34 |
| 0.60 | 117.27 | 0.76 | 1493.00 | 1556.10 | 1587.67 | 3143.76 | 32.67 | 32.67 | 96.78 | 98.75 | 195.53 | 29.72 | 439.86 | 10.30 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 152.32 | 1.43 | 2119.91 | 793.91 | 776.52 | 1570.43 | 103.87 | 103.92 | 157.02 | 153.64 | 310.66 | 29.76 | 504.61 | 12 19 |
| 0.32 | 140.08 | 1.50 | 1887.65 | 849.20 | 829.10 | 1678.30 | 92.84 | 92.86 | 150.11 | 146.59 | 296.70 | 29.74 | 481.95 | 11.50 |
| 0.33 | 132.78 | 1.36 | 1751.36 | 852.64 | 877.86 | 1730.50 | 86.19 | 86.21 | 139.92 | 144.10 | 284.03 | 29.70 | 468.64 | 11.04 |
| 0.34 | 126.54 | 1.50 | 1646.27 | 869.27 | 902.41 | 1771.68 | 80.73 | 80.74 | 133.61 | 138.73 | 272.34 | 29.68 | 456.59 | 10.61 |
| ***Configuration 3*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.30 | 176.57 | 0.41 | 2308.55 | 805.68 | 783.91 | 1589.59 | 113.27 | 113.25 | 173.76 | 169.03 | 342.79 | 29.20 | 528.18 | 19.95 |
| 0.33 | 170.64 | 0.40 | 2148.70 | 876.40 | 844.25 | 1720.65 | 105.52 | 105.55 | 176.08 | 169.66 | 345.74 | 29.20 | 518.45 | 19.87 |
| 0.35 | 158.79 | 0.52 | 1968.29 | 931.90 | 895.57 | 1827.48 | 96.76 | 96.78 | 171.69 | 165.03 | 336.72 | 29.21 | 502.24 | 19.94 |
| 0.35 | 159.89 | 0.70 | 1991.30 | 919.26 | 893.39 | 1812.65 | 97.86 | 97.77 | 171.28 | 166.31 | 337.58 | 28.88 | 504.13 | 19.92 |
| 0.37 | 138.55 | 0.57 | 1661.33 | 986.90 | 947.62 | 1934.52 | 81.63 | 81.61 | 153.39 | 147.25 | 300.64 | 28.90 | 467.62 | 19.56 |
| 0.45 | 143.56 | 0.68 | 1748.36 | 1193.73 | 1149.23 | 2342.95 | 60.45 | 60.53 | 137.38 | 132.44 | 269.82 | 28.90 | 479.00 | 19.89 |
| 0.50 | 137.84 | 0.52 | 1665.86 | 1328.43 | 1277.10 | 2605.52 | 51.76 | 51.79 | 130.91 | 125.92 | 256.83 | 28.89 | 469.48 | 19.67 |
| 0.55 | 134.05 | 0.68 | 1609.95 | 1455.86 | 1391.64 | 2847.50 | 44.73 | 44.72 | 123.98 | 118.49 | 242.47 | 28.88 | 463.27 | 19.51 |
| 0.60 | 130.93 | 1.00 | 1565.09 | 1583.68 | 1521.18 | 3104.86 | 38.25 | 38.25 | 115.34 | 110.80 | 226.13 | 28.89 | 458.32 | 19.38 |
| **105°F** | | | | | | | | | | | | | | |
| 0.30 | 175.64 | 0.36 | 2322.41 | 777.68 | 781.73 | 1559.41 | 114.04 | 114.10 | 168.86 | 169.83 | 338.69 | 29.27 | 535.64 | 20.16 |
| 0.33 | 167 66 | 0.45 | 2119.82 | 883.59 | 856.18 | 1739.77 | 103.95 | 103.90 | 174.87 | 169.38 | 344.25 | 29.27 | 522.09 | 20 03 |
| 0.35 | 157.24 | 0.71 | 1963.62 | 926.81 | 895.67 | 1822.48 | 96.36 | 96.28 | 170.04 | 164 18 | 334.22 | 29.25 | 506.24 | 20.09 |
| 0.37 | 136.94 | 0.62 | 1648.05 | 983.00 | 948.62 | 1931.62 | 80.91 | 80.92 | 151.43 | 146.15 | 297.59 | 29.21 | 470.00 | 19.70 |
| 0.45 | 141.73 | 0.59 | 1728.00 | 1217.73 | 1145.05 | 2362.77 | 59.30 | 59.29 | 137.50 | 129.25 | 266.75 | 29.19 | 481.18 | 20.02 |
| 0.50 | 136.89 | 0.62 | 1650.00 | 1341.62 | 1272.71 | 2614.33 | 51.30 | 51.29 | 131.05 | 124.28 | 255.33 | 29.17 | 472.48 | 19.80 |
| **115°F** | | | | | | | | | | | | | | |
| 0.35 | 154.33 | 0.65 | 1924.61 | 931.78 | 896.78 | 1828.57 | 94.78 | 94.78 | 168.15 | 161.84 | 329.99 | 29.32 | 491.35 | 20.16 |
| 0.37 | 135.84 | 0.86 | 1636.32 | 979.91 | 949.55 | 1929.45 | 80.42 | 80.45 | 150.04 | 145.45 | 295.49 | 29.32 | 466.23 | 19.64 |
| 0.37 | 134.05 | 0.60 | 1610.00 | 975.75 | 947.60 | 1923.35 | 79.29 | 79.27 | 147.30 | 143.02 | 290.32 | 29.32 | 462.35 | 19.52 |
| Spreadsheet Notes | | | | | | calc | | | calc | calc | calc | | | |

Dyno Torque Values all need to be multiplied by a factor of 10

Missing Data indicates channel was bad and results were deleted on purpose

| TE/WT at Temp | CLNT FLOW | SURGE FLOW | CELL DEP H2O | AIR B4 FILTER p | AIR B4 TURBO f | AIR B4 TURBO p | AIR AFT TURBO f | AIR BOX TEMP | AIR BOX PSI | EX B4 TURBO p | EX AFT TURBO p | ENG OIL SUMP | OIL TEMP GALLERY | OIL PSI GALLERY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.35 | 85.49 | 0.12 | -0.21 | -0.71 | 102.14 | -13.41 | 283.01 | 278.85 | 15.70 | 11.74 | 40.28 | 235.48 | 208.49 | 46.04 |
| 0.45 | 88.86 | 0 15 | -0.20 | -0.72 | 105.26 | -14.09 | 293.37 | 292.05 | 16.40 | 12.27 | 42.42 | 248.05 | 220.45 | 45.06 |
| 0.50 | 86.16 | 0.17 | -0.21 | -0.71 | 106.30 | -13.56 | 290.04 | 289.68 | 15.87 | 11.85 | 40.77 | 247.29 | 221.27 | 43.86 |
| 0.55 | 84.84 | 0.17 | -0.21 | -0.70 | 107.50 | -13.26 | 288.74 | 288.73 | 15.54 | 11.60 | 39.80 | 250.00 | 223.59 | 42.41 |
| 0.60 | 84.06 | 0.18 | -0.21 | -0.68 | 108.16 | -13.06 | 287.84 | 287.00 | 15.35 | 11.44 | 39.23 | 252.21 | 225.70 | 41.26 |
| **105°F** | | | | | | | | | | | | | | |
| 0.26 | 124.84 | 1.80 | -0.21 | -0.91 | 113.25 | -19.14 | 348.59 | 359.85 | 21.65 | 16.28 | 57.35 | 259.73 | 230.86 | 60.48 |
| 0.31 | 106.52 | 0.52 | -0.21 | -0.78 | 116.06 | -16.03 | 325.62 | 313.84 | 18.36 | 13.75 | 47 63 | 254.47 | 226.50 | 50.92 |
| 0.32 | 97.20 | 0.20 | -0.21 | -0.72 | 117.50 | -14.43 | 312.74 | 302.40 | 16.67 | 12 42 | 42.72 | 253.07 | 225.60 | 46.23 |
| 0.33 | 91.86 | 0.14 | -0.21 | -0.70 | 118.18 | -13.49 | 305.05 | 298.07 | 15.71 | 11.68 | 39.85 | 250.55 | 224.54 | 44.16 |
| 0.35 | 99.47 | 0.22 | -0.21 | -0.73 | 119.58 | -14.74 | 318.15 | 311.67 | 16.99 | 12.66 | 43.58 | 262.94 | 237.47 | 44 74 |
| 0.40 | 95 26 | 0.25 | -0.21 | -0.72 | 114.10 | -14.21 | 304.27 | 302.37 | 16.46 | 12.22 | 41.62 | 258.85 | 231.94 | 44 43 |
| 0.45 | 91.82 | 0 20 | -0.21 | -0.70 | 116.07 | -13.59 | 301.24 | 301.42 | 15.82 | 11.73 | 39.56 | 259.01 | 232.80 | 42.47 |
| 0.50 | 89.66 | 0.19 | -0.21 | -0.69 | 117.50 | -13.15 | 298.80 | 298.75 | 15.36 | 11.38 | 38.22 | 258.03 | 233.73 | 40.98 |
| 0.55 | 88.37 | 0.20 | -0.21 | -0.67 | 118.95 | -12.86 | 297.77 | 297.28 | 15.05 | 11.12 | 37.34 | 261.06 | 236.17 | 39.71 |
| 0.60 | 87.28 | 0.17 | -0.21 | -0.67 | 119.95 | -12.62 | 296.73 | 295.99 | 14.80 | 10.92 | 36.64 | 263.46 | 238.63 | 38.61 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 103.40 | 0.38 | -0.21 | -0.76 | 127.31 | -15.52 | 337.21 | 323.80 | 17 89 | 13.29 | 46.37 | 265.17 | 237.73 | 48.17 |
| 0.32 | 94.07 | 0.17 | -0.21 | -0.71 | 128.78 | -13.96 | 324.65 | 316.16 | 16.28 | 12.02 | 41.63 | 264.42 | 236.55 | 44.05 |
| 0.33 | 86.04 | 0.11 | -0.21 | -0.66 | 129.67 | -12.58 | 312.27 | 302.61 | 14.85 | 10.91 | 37.40 | 261.34 | 235.57 | 39.57 |
| ***Configuration 2*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.294 | 121.03 | 1.12 | -0.21 | -0.46 | 102.18 | -19.27 | 331 15 | 332.22 | 21 49 | 16.32 | 55.09 | 248.67 | 220 13 | 60.25 |
| 0.33 | 102.78 | 0 13 | -0.21 | -0.43 | 104.10 | -16.02 | 306.16 | 295 70 | 18.06 | 13.62 | 45.37 | 244.86 | 216.83 | 50.31 |
| 0.35 | 90.62 | 0.07 | -0.21 | -0.40 | 105.55 | -13.89 | 289.52 | 285.10 | 15.87 | 11.93 | 39.22 | 240.06 | 214.32 | 43.61 |
| 0.35 | 91.34 | 0.11 | -0.21 | -0.72 | 105.57 | -14.32 | 293.29 | 287.00 | 16.08 | 12.11 | 39 80 | 239.93 | 213.72 | 44.25 |
| 0.40 | 94.31 | 0.14 | -0.21 | -0.72 | 108.12 | -14.83 | 301.19 | 299.05 | 16.58 | 12.49 | 41 25 | 251.30 | 225.06 | 43.52 |
| 0.45 | 89.94 | 0.13 | -0.21 | -0.70 | 109.13 | -14.01 | 295 11 | 291 12 | 15.75 | 11.85 | 38 92 | 249.69 | 224.28 | 41 40 |
| 0.50 | 85.75 | 0.10 | -0.21 | -0.68 | 110.60 | -13.22 | 289.55 | 281.15 | 14.93 | 11 18 | 36.72 | 251.15 | 226.09 | 38.46 |
| 0.55 | 83.27 | 0.10 | -0.21 | -0.66 | 111.71 | -12.73 | 286.12 | 277.87 | 14.41 | 10.79 | 35.30 | 252.91 | 228.34 | 36.53 |
| 0.60 | 81.18 | 0 11 | -0.21 | -0.65 | 112.32 | -12.40 | 283.55 | 275.94 | 14.06 | 10.52 | 34.32 | 255.60 | 231.08 | 34.76 |
| **105°F** | | | | | | | | | | | | | | |
| 0.307 | 115.46 | 0.98 | -0.21 | -0.84 | 113.89 | -18.17 | 334.20 | 326.09 | 20.07 | 15.15 | 50.81 | 256.45 | 228.12 | 54.57 |
| 0.33 | 99.76 | 0.18 | -0.21 | -0.73 | 116.20 | -15.44 | 313.20 | 305.03 | 17 19 | 12.89 | 42.75 | 252.29 | 226.17 | 46.24 |
| 0.40 | 93.38 | 0.20 | -0.21 | -0.70 | 118.74 | -14 27 | 306.64 | 305.39 | 16.04 | 11.98 | 39.49 | 260.57 | 234.53 | 41.57 |
| 0.45 | 88.54 | 0.25 | -0.21 | -0.67 | 119.55 | -13.35 | 299.18 | 294.78 | 15.10 | 11.24 | 36.92 | 258.76 | 233.48 | 39.05 |
| 0.50 | 85.46 | 0.25 | -0 21 | -0 64 | 120.77 | -12.81 | 295.75 | 287.73 | 14.59 | 10.82 | 35.54 | 259.63 | 234.59 | 37.10 |
| 0.55 | 82.93 | 0.21 | -0.21 | -0.63 | 121.66 | -12 35 | 292.50 | 284.57 | 14 11 | 10.47 | 34.28 | 260.31 | 236.47 | 35.31 |
| 0.60 | 80.29 | 0.22 | -0.22 | -0.61 | 122.06 | -11.98 | 289.45 | 281.98 | 13.75 | 10.19 | 33.30 | 262.66 | 238.70 | 33.71 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 118.75 | 1.15 | -0.21 | -0.80 | 121.43 | -17 68 | 343.36 | 335.98 | 20.07 | 15.07 | 50.54 | 265.35 | 237.04 | 52 28 |
| 0.32 | 104.38 | 0.41 | -0.21 | -0.72 | 124.58 | -15.47 | 327.95 | 318.42 | 17.72 | 13.21 | 43.96 | 263.45 | 236.02 | 46.23 |
| 0.33 | 96.67 | 0.25 | -0.22 | -0.68 | 126.31 | -14.24 | 319.20 | 313.83 | 16.43 | 12.22 | 40.41 | 261.60 | 234.85 | 43.15 |
| 0.34 | 90.45 | 0 18 | -0.21 | -0.63 | 128.81 | -13.15 | 312.07 | 305.93 | 15.29 | 11.33 | 37.23 | 260.43 | 234.72 | 39.87 |
| ***Configuration 3*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.30 | 140.29 | 0.01 | -0.21 | -0.80 | 103.79 | -20.68 | 341.72 | 312.24 | 21.21 | 16.14 | 56.94 | 270.51 | 243 08 | 61.33 |
| 0.33 | 130.87 | 0.01 | -0.21 | -0.76 | 105.05 | -19.84 | 336.29 | 303.29 | 20.25 | 15.49 | 54.26 | 269.92 | 242.60 | 59.38 |
| 0.35 | 120.18 | 0.00 | -0.21 | -0 71 | 106.31 | -18 34 | 323.39 | 281.39 | 18 54 | 14 17 | 49.63 | 267.00 | 239.58 | 55 41 |
| 0.35 | 121.28 | | -0.21 | -0.71 | 105 20 | -18.64 | 326.50 | 282.98 | 18.81 | 14.38 | 50.43 | 267 70 | 240.43 | 55.78 |
| 0.37 | 101.12 | | -0.21 | -0.61 | 107.50 | -15.46 | 300.15 | 257.85 | 15.61 | 11.87 | 40.99 | 263.28 | 235.47 | 45.19 |
| 0.45 | 106.12 | | -0.21 | -0.64 | 108.88 | -16.48 | 311 19 | 272.31 | 16.57 | 12.62 | 43.88 | 273.97 | 246.29 | 45.20 |
| 0.50 | 101.14 | | -0.21 | -0.61 | 109.45 | -15.57 | 303 76 | 270 06 | 15.69 | 11 93 | 41.19 | 273 78 | 245.94 | 42.37 |
| 0.55 | 97.84 | | -0.21 | -0.59 | 110.21 | -15.05 | 300.01 | 267.93 | 15.19 | 11.51 | 39.74 | 274 73 | 247.09 | 40.09 |
| 0.60 | 95.04 | | -0.21 | -0.58 | 110.67 | -14.64 | 296.60 | 266.57 | 14.78 | 11.17 | 38.56 | 276.65 | 248.88 | 38.01 |
| **105°F** | | | | | | | | | | | | | | |
| 0.30 | 141.47 | 1.45 | -0.21 | -0.77 | 108.81 | -20.27 | 346 10 | 321.56 | 21.03 | 15.90 | 56.61 | 277.68 | 250.35 | 61.13 |
| 0.33 | 128.99 | 0.00 | -0.21 | -0.72 | 111 24 | -19.10 | 339.20 | 305.50 | 19.70 | 14.99 | 52.98 | 275.90 | 249.29 | 58.34 |
| 0.35 | 119 61 | 0.00 | -0.21 | -0.67 | 112.72 | -17.73 | 328.43 | 286 74 | 18.22 | 13.84 | 48.79 | 273.10 | 246.34 | 54.36 |
| 0.37 | 100.01 | 0.00 | -0.22 | -0.58 | 115.61 | -14.81 | 304.84 | 265.89 | 15.25 | 11.51 | 40.01 | 269.66 | 242.25 | 43 47 |
| 0.45 | 104.93 | 0.00 | -0.21 | -0.61 | 116.30 | -15.73 | 314.81 | 278.85 | 16.14 | 12.22 | 42.69 | 279.96 | 252.75 | 43.81 |
| 0.50 | 100.42 | 0.00 | -0.21 | -0.59 | 117 17 | -14 98 | 309.22 | 276.99 | 15.42 | 11.64 | 40.51 | 280.23 | 252.83 | 41.14 |
| **115°F** | | | | | | | | | | | | | | |
| 0.35 | | | -0.21 | -0.65 | 123.53 | -18.20 | 339.30 | 293.59 | 17.80 | 13.48 | 45.73 | 284.83 | 256.93 | 45.84 |
| 0.37 | | | -0.21 | -0.57 | 120.79 | -15 41 | 311 30 | 273 49 | 15.19 | 11.42 | 38.40 | 278.12 | 250.56 | 40.80 |
| 0.37 | | | -0.22 | -0.56 | 125.75 | -15.19 | 314 16 | 273.84 | 14.87 | 11 16 | 37.47 | 280.20 | 252.55 | 38.94 |

| TE/WT at Temp | OIL B4 ENG CLR | TRANS OI SUMP | TRANS MAIN psi | OIL B4 TRAN CLR | OIL AFT TRAN CLR | FUEL SUP 'f | FUEL RET 'f | FUEL SUP psi | FUEL AFT PUMP psi | FUEL RET psi | CLNT B4 RAD psi | CLNT AFT RAD psi | CLNT AFT T CLR | CLNT B4 AFT CLR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.35 | 232.46 | 204.89 | 145.03 | 207.62 | 194.86 | 128.70 | 167.95 | 4.06 | 72 65 | 1.03 | 15.97 | 11.64 | 189.52 | 113.91 |
| 0.45 | 243.68 | 221.53 | 206.44 | 237.20 | 219.35 | 123.73 | 172.16 | 4.05 | 73.21 | 1.02 | 19.03 | 14.52 | 202.40 | 114.82 |
| 0.50 | 244.61 | 223.55 | 206.14 | 240.28 | 221.52 | 123.19 | 171.60 | 4.02 | 72.68 | 1.02 | 18.74 | 14.50 | 203.50 | 114.69 |
| 0.55 | 246.69 | 227.53 | 206.03 | 246.43 | 225.72 | 123.10 | 172.14 | 4.00 | 72.51 | 1 03 | 17 52 | 13.54 | 206.08 | 115.41 |
| 0.60 | 248.75 | 231.82 | 205.92 | 253.39 | 230.25 | 122.90 | 172.47 | 3.99 | 72.25 | 1.03 | 15.86 | 12.15 | 208.51 | 115.15 |
| **105°F** | | | | | | | | | | | | | | |
| 0.26 | 253.85 | 231.03 | 148.06 | 235.04 | 217.00 | 140.60 | 198.51 | 4.42 | 78.22 | 0.89 | 16.94 | 10.85 | 210.40 | 125.85 |
| 0.31 | 249.30 | 224.52 | 145.79 | 228.11 | 213.02 | 140.46 | 188.60 | 4.18 | 74.27 | 1.06 | 13.16 | 8.95 | 207.44 | 126.32 |
| 0.32 | 248.30 | 223.10 | 143.90 | 226.40 | 212.46 | 140.60 | 184.55 | 4.16 | 73.19 | 1.12 | 11.95 | 8.52 | 206.98 | 126.53 |
| 0.33 | 247 33 | 221.24 | 143.26 | 224.24 | 211.48 | 140.62 | 182.23 | 4.14 | 72.49 | 1.13 | 11.04 | 8.04 | 206.40 | 126.50 |
| 0.35 | 259.31 | 240.29 | 205.53 | 257.20 | 237.98 | 141.06 | 190.17 | 4.13 | 73.39 | 1.11 | 13.42 | 9.58 | 220.00 | 127.30 |
| 0.40 | 253.77 | 232.45 | 205.45 | 248.05 | 230.68 | 139.94 | 186.27 | 4.34 | 72.90 | 1.24 | 15.71 | 12.19 | 214.69 | 126.21 |
| 0.45 | 254.78 | 233.67 | 205.01 | 249.33 | 231.84 | 140.58 | 185.73 | 4.33 | 72.50 | 1.25 | 14.47 | 11.27 | 215.93 | 126.79 |
| 0.50 | 255.56 | 236.04 | 204.61 | 253.08 | 234.40 | 141.21 | 185.38 | 4.33 | 72 12 | 1.25 | 13.58 | 10.58 | 217.12 | 126.97 |
| 0.55 | 257 80 | 240.75 | 204.19 | 260.50 | 239.46 | 140.59 | 185.99 | 4.35 | 71.74 | 1.26 | 13 03 | 10.17 | 219.77 | 127.17 |
| 0.60 | 260.02 | 245.88 | 203.88 | 268.60 | 244.76 | 140.39 | 186.54 | 4.28 | 71.29 | 1.28 | 12.98 | 10.15 | 222.63 | 127.56 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 260.23 | 236.21 | 144.36 | 239.61 | 225.57 | 140.65 | 195.56 | 4.44 | 73.74 | 1.38 | 14.27 | 9.93 | 220.50 | 139.60 |
| 0.32 | 259.20 | 234.74 | 142.49 | 237.94 | 224.78 | 141.58 | 191 20 | 4.41 | 72.69 | 1.44 | 13.18 | 9.68 | 219.91 | 139.43 |
| 0.33 | 258.45 | 232.80 | 141.94 | 235.65 | 223.79 | 140.49 | 188.03 | 4.42 | 71.38 | 1.45 | 12.33 | 9 45 | 219.38 | 139.12 |
| ***Configuration 2*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.294 | 242.82 | 221.03 | 149.76 | 223.66 | 206.22 | 139.11 | 189.33 | 1.50 | 73.77 | 1.30 | 13.32 | 7.41 | 199.80 | 122.93 |
| 0.33 | 239.86 | 215.69 | 146.81 | 217.89 | 203.11 | 139.59 | 180.15 | 1.31 | 71.09 | 1.50 | 9.92 | 5.86 | 197.65 | 122.84 |
| 0.35 | 237.59 | 211.45 | 145.61 | 213.27 | 200.94 | 139.22 | 175.20 | 1.30 | 69.69 | 1.55 | 8.23 | 5.17 | 196.43 | 123.02 |
| 0.35 | 237.05 | 209.92 | 145.78 | 211.77 | 200.05 | 140.37 | 175.74 | 1 29 | 69.84 | 1.54 | 10.17 | 6.23 | 195.70 | 122.89 |
| 0.40 | 247.57 | 226.04 | 206.71 | 239.43 | 224.15 | 141.09 | 182.60 | 1.30 | 70.17 | 1.53 | 10.57 | 6.35 | 208.08 | 124.74 |
| 0.45 | 247.02 | 225.06 | 206.49 | 237.65 | 223.09 | 140.10 | 180.25 | 1 29 | 69.46 | 1.53 | 9.35 | 5.67 | 207.57 | 124.58 |
| 0.50 | 248.70 | 228.38 | 206.02 | 243.05 | 226.93 | 140.37 | 179.64 | 1 23 | 68.56 | 1.57 | 8.46 | 5.21 | 210.03 | 126.00 |
| 0.55 | 250.75 | 233.16 | 205.57 | 250.65 | 231.93 | 140.47 | 179.95 | 1.24 | 67.85 | 1.60 | 8.11 | 5.05 | 212.61 | 126.20 |
| 0.60 | 253.40 | 239.22 | 205.33 | 260.24 | 238.28 | 140 72 | 180.56 | 1 24 | 67.48 | 1.61 | 8.26 | 5.18 | 215.82 | 126.14 |
| **105°F** | | | | | | | | | | | | | | |
| 0.307 | 250.70 | 228.05 | 148.10 | 230.65 | 214.99 | 140.46 | 192.78 | 1.42 | 72.54 | 1.42 | 13.31 | 8.18 | 209.42 | 133.14 |
| 0.33 | 248.83 | 224.72 | 145.13 | 226.96 | 213.42 | 140.66 | 186.34 | 1.32 | 70.58 | 1.58 | 10.57 | 6.90 | 208.50 | 133.68 |
| 0 40 | 256.63 | 235.08 | 205.88 | 247.93 | 233.25 | 141.35 | 188.27 | 1.35 | 69.60 | 1.63 | 10.72 | 7.23 | 218.35 | 134.81 |
| 0.45 | 255.66 | 233.93 | 205.56 | 246.48 | 232.14 | 140.65 | 185.46 | 1.29 | 68.72 | 1.66 | 9.39 | 6.41 | 217.58 | 134.28 |
| 0.50 | 256.81 | 236.79 | 205.18 | 251.20 | 235 12 | 140.36 | 184.84 | 1 27 | 68.10 | 1.70 | 9.07 | 6.28 | 219.06 | 134.16 |
| 0.55 | 258.39 | 241.18 | 204.85 | 258.37 | 239.87 | 140.90 | 184.95 | 1 29 | 67.46 | 1.72 | 9.29 | 6.49 | 221.34 | 134.81 |
| 0.60 | 260.50 | 246.83 | 204.49 | 267.90 | 245.80 | 140.43 | 185.03 | 1 27 | 67.12 | 1.71 | 9.90 | 6.93 | 223.82 | 133.98 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 259.27 | 237.69 | 147.16 | 239.90 | 224 77 | 140.91 | 199.44 | 1.45 | 72.31 | 1 52 | 15 18 | 10.35 | 219.68 | 143.54 |
| 0 32 | 258.30 | 235.51 | 144.88 | 237.41 | 223.88 | 140.63 | 194.07 | 1 35 | 70 72 | 1.66 | 12.46 | 8.79 | 219.17 | 144.18 |
| 0.33 | 257.26 | 233.28 | 143.81 | 235.24 | 222.81 | 140.39 | 191.18 | 1 36 | 69 73 | 1.71 | 10.85 | 7.87 | 218.62 | 144.15 |
| 0.34 | 257.27 | 232.33 | 143.42 | 234.00 | 222.83 | 140.90 | 188.39 | 1.36 | 69.02 | 1.75 | 9.50 | 7.03 | 219.12 | 144.88 |
| ***Configuration 3*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.30 | 265.31 | 231.08 | 149.10 | 233.40 | 217 39 | 136.14 | 197.04 | 4 13 | 79.53 | 1.59 | 20.70 | 13.56 | 210.00 | 213.40 |
| 0.33 | 265.03 | 230.46 | 148.06 | 232.67 | 217.35 | 136.30 | 192.17 | 3.98 | 77.24 | 1.76 | 19.58 | 13.09 | 210.09 | 214.64 |
| 0.35 | 261.92 | 226.61 | 146.51 | 228.61 | 214.39 | 136.84 | 186.72 | 3.94 | 75.38 | 1.86 | 17.96 | 12.14 | 207.60 | 215.55 |
| 0.35 | 262.67 | 226.50 | 146.70 | 228.63 | 215.09 | 136.81 | 187.57 | 3.95 | 75.43 | 1.86 | 19.60 | 13.84 | 208.67 | 239.31 |
| 0.37 | 257.94 | 220.32 | 144.27 | 222.04 | 210.95 | 136.67 | 177.06 | 3.80 | 71.64 | 2.13 | 17.23 | 12.63 | 205.07 | 230.14 |
| 0.45 | 268.42 | 233.89 | 205.76 | 247.74 | 232.16 | 136.62 | 184.95 | 3.87 | 72.84 | 2.03 | 19.09 | 14.37 | 216.98 | 275.64 |
| 0.50 | 268.25 | 234.09 | 205.36 | 248.25 | 232.43 | 136.35 | 181.84 | 3.80 | 71.57 | 2.14 | 18.48 | 13.98 | 217.10 | 234.33 |
| 0.55 | 269.34 | 236.66 | 205.62 | 253.05 | 235.50 | 136.55 | 181.17 | 3.81 | 71.00 | 2.17 | 18.26 | 13.93 | 218.84 | 224.66 |
| 0.60 | 271.20 | 240.82 | 204.66 | 260.38 | 239.95 | 136.65 | 180.91 | 3.80 | 70.63 | 2.19 | 18.26 | 14.10 | 221.08 | 228.15 |
| **105°F** | | | | | | | | | | | | | | |
| 0.30 | 272.27 | 239.06 | 148.32 | 241.61 | 225.48 | 136.70 | 202.11 | 4.35 | 79.34 | 1.68 | 21 95 | 14.61 | 218.79 | 221.50 |
| 0.33 | 271.33 | 237.72 | 146.86 | 239.86 | 224.78 | 136.62 | 196.00 | 4.17 | 76.48 | 1.88 | 20 18 | 13.70 | 218.36 | 221.14 |
| 0.35 | 268.43 | 234.04 | 145.42 | 235.95 | 222.11 | 136.31 | 191.09 | 4.14 | 74.99 | 1.95 | 18.54 | 12.70 | 215.90 | 218.64 |
| 0.37 | 264.71 | 227.83 | 143.48 | 229.50 | 218.53 | 137.00 | 181 46 | 4 01 | 71 38 | 2.21 | 16.39 | 11.74 | 212.94 | 215.72 |
| 0.45 | 274.85 | 241.34 | 204.94 | 254.93 | 239.18 | 136.56 | 187 79 | 3.97 | 72.02 | 2.19 | 18.74 | 13.89 | 224.73 | 229.11 |
| 0.50 | 274.97 | 241.92 | 204.57 | 256.04 | 240.11 | 136.50 | 186.50 | 3.98 | 71 41 | 2.20 | 18.33 | 13.66 | 225.11 | 229.67 |
| **115°F** | | | | | | | | | | | | | | |
| 0.35 | 279.49 | 243.42 | 144.09 | 245.43 | 233.65 | 136.45 | 197.04 | 4.34 | 74.38 | 1.99 | 20.21 | 14.81 | 227.17 | 230.67 |
| 0.37 | 272.50 | 235.04 | 142.65 | 236.56 | 227.51 | 136.64 | 185.95 | 4 18 | 70.91 | 2.24 | 19.11 | 14.76 | 221 61 | 225.25 |
| 0.37 | 274.75 | 237.92 | 142.30 | 239.43 | 229.98 | 136.64 | 186.39 | 4.10 | 70.62 | 2.25 | 17.89 | 13.55 | 223.78 | 227.34 |

| TE/WT at Temp | CLNT AFT AFT CLR | CLNT B4 PUMP p | CELL AMB T/L | CELL AMB B/L | CELL AMB T/R | CELL AMB B/R | AIR B4 INLET 1 | AIR B4 INLET 2 | AIR B4 INLET 3 | AIR B4 INLET 4 | AIR B4 INLET 5 | AIR B4 INLET 6 | AIR B4 INLET 7 | AVERAGE Air B4 Inlet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.35 | 116.85 | 12.00 | 95.73 | 97.85 | 93.54 | 93.77 | 98.44 | 99.42 | 98.05 | 98.05 | 97.95 | 98.32 | 97.80 | |
| 0.45 | 117.93 | 14.74 | 95.89 | 98.21 | 93.56 | 93.87 | 98.75 | 99.66 | 98.13 | 98.08 | 98.12 | 98.80 | 97.77 | |
| 0.50 | 117.82 | 14.72 | 95.69 | 97.92 | 93.11 | 93.72 | 98.50 | 99.26 | 97.68 | 97.41 | 97.76 | 98.45 | 96.93 | |
| 0.55 | 118.61 | 13.64 | 95.78 | 97.97 | 93.36 | 93.77 | 98.77 | 99.59 | 98.01 | 97.83 | 98.22 | 99.01 | 97.39 | |
| 0.60 | 118.50 | 12.07 | 95.18 | 97.76 | 93.33 | 93.60 | 98.64 | 99.64 | 98.20 | 97.99 | 97.65 | 98.65 | 97.51 | |
| **105°F** | | | | | | | | | | | | | | |
| 0.26 | 128.73 | 10.12 | 105.47 | 105.33 | 104.20 | 104.44 | 108.58 | 109.13 | 107.84 | 107.60 | 107.26 | 108.08 | 107.15 | |
| 0.31 | 129.43 | 8.18 | 106.16 | 106.28 | 105.03 | 105.20 | 109.87 | 110.61 | 109.32 | 109.15 | 108.41 | 109.43 | 108.70 | |
| 0.32 | 130.01 | 7.69 | 106.22 | 106.31 | 104.86 | 105.08 | 110.04 | 110.84 | 109.54 | 109.32 | 108.53 | 109.52 | 108.80 | |
| 0.33 | 130.06 | 7.15 | 106.17 | 106.19 | 104.79 | 105.03 | 110.13 | 110.99 | 109.75 | 109.48 | 108.58 | 109.70 | 108.86 | |
| 0.35 | 131.10 | 9.01 | 106.18 | 106.24 | 104.69 | 104.77 | 109.95 | 110.74 | 109.35 | 109.08 | 108.43 | 109.80 | 108.62 | |
| 0.40 | 130.11 | 11.86 | 106.70 | 106.22 | 104.11 | 104.35 | 109.79 | 110.46 | 108.88 | 108.77 | 109.14 | 109.69 | 108.46 | |
| 0.45 | 130.71 | 10.81 | 106.94 | 106.31 | 104.03 | 104.31 | 110.01 | 110.59 | 109.02 | 108.88 | 109.40 | 110.10 | 108.72 | |
| 0.50 | 131.05 | 10.07 | 106.86 | 106.39 | 104.25 | 104.47 | 110.23 | 110.82 | 109.26 | 109.25 | 109.42 | 110.28 | 109.00 | |
| 0.55 | 131.33 | 9.63 | 107.10 | 106.77 | 104.42 | 104.58 | 110.44 | 111.21 | 109.56 | 109.46 | 109.62 | 110.61 | 109.22 | |
| 0.60 | 131.82 | 9.64 | 107.27 | 107.05 | 104.82 | 104.86 | 110.95 | 111.67 | 110.00 | 109.92 | 109.92 | 110.87 | 109.65 | |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 141.87 | 8.88 | 118.76 | 118.04 | 116.32 | 116.35 | 122.35 | 123.16 | 121.64 | 121.62 | 121.52 | 122.40 | 121.59 | 122.04 |
| 0.32 | 142.05 | 8.61 | 117.96 | 117.15 | 115.59 | 115.49 | 121.65 | 122.46 | 121.00 | 120.98 | 120.75 | 121.75 | 120.85 | 121.35 |
| 0.33 | 142.01 | 8.39 | 117.07 | 116.28 | 114.90 | 114.73 | 121.14 | 122.01 | 120.61 | 120.69 | 120.05 | 121.31 | 120.66 | 120.92 |
| ***Configuration 2*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.294 | 118.62 | 6.50 | 96.15 | 96.10 | 94.42 | 94.00 | 98.95 | 99.88 | 98.77 | 98.60 | 97.82 | 98.62 | 98.45 | |
| 0.33 | 118.88 | 5.08 | 96.16 | 95.97 | 94.40 | 93.99 | 99.20 | 100.31 | 99.27 | 99.36 | 98.07 | 98.96 | 98.89 | |
| 0.35 | 119.51 | 4.45 | 96.06 | 95.87 | 94.56 | 94.31 | 99.47 | 100.78 | 99.94 | 100.05 | 98.43 | 99.42 | 99.57 | |
| 0.35 | 119.17 | 5.57 | 95.91 | 95.41 | 93.88 | 93.78 | 99.17 | 100.17 | 98.99 | 99.16 | 98.21 | 99.17 | 99.10 | |
| 0.40 | 120.59 | 5.70 | 96.48 | 95.98 | 94.43 | 94.31 | 99.70 | 100.71 | 99.49 | 99.63 | 98.42 | 99.79 | 99.60 | |
| 0.45 | 120.56 | 5.00 | 95.86 | 95.27 | 93.83 | 93.80 | 99.19 | 100.16 | 98.95 | 99.14 | 97.90 | 99.38 | 99.15 | |
| 0.50 | 122.10 | 4.54 | 97.09 | 96.18 | 94.84 | 94.94 | 100.63 | 101.65 | 100.29 | 100.45 | 99.30 | 100.72 | 100.37 | |
| 0.55 | 122.25 | 4.39 | 96.89 | 96.00 | 94.75 | 94.77 | 100.57 | 101.54 | 100.30 | 100.47 | 99.20 | 100.69 | 100.44 | |
| 0.60 | 122.20 | 4.54 | 96.56 | 95.63 | 94.44 | 94.40 | 100.20 | 101.20 | 99.99 | 100.15 | 98.91 | 100.50 | 100.11 | |
| **105°F** | | | | | | | | | | | | | | |
| 0.307 | 129.29 | 7.11 | 106.37 | 105.92 | 104.13 | 103.53 | 109.43 | 110.56 | 109.30 | 109.23 | 108.34 | 109.08 | 108.96 | |
| 0.33 | 130.19 | 5.88 | 106.62 | 106.27 | 104.72 | 104.17 | 110.03 | 111.39 | 110.07 | 110.08 | 108.80 | 109.69 | 109.76 | |
| 0.40 | 131.37 | 6.29 | 106.82 | 106.58 | 104.96 | 104.37 | 110.47 | 111.93 | 110.53 | 110.60 | 109.40 | 110.40 | 110.29 | |
| 0.45 | 130.90 | 5.48 | 106.47 | 106.30 | 104.85 | 104.34 | 110.30 | 111.81 | 110.56 | 110.62 | 109.11 | 110.21 | 110.33 | |
| 0.50 | 130.84 | 5.36 | 105.82 | 105.66 | 104.43 | 103.94 | 109.92 | 111.41 | 110.11 | 110.16 | 108.44 | 109.85 | 109.92 | |
| 0.55 | 131.60 | 5.58 | 106.64 | 106.51 | 105.05 | 104.48 | 110.71 | 112.31 | 110.93 | 111.02 | 109.45 | 110.66 | 110.71 | |
| 0.60 | 130.69 | 6.08 | 105.34 | 105.18 | 103.82 | 103.19 | 109.63 | 111.19 | 109.89 | 109.98 | 108.29 | 109.72 | 109.78 | |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 140.10 | 9.22 | 117.20 | 115.11 | 113.33 | 112.77 | 119.61 | 120.50 | 118.77 | 119.35 | 119.90 | 120.31 | 119.85 | 119.76 |
| 0.32 | 140.94 | 7.72 | 117.72 | 115.91 | 114.17 | 113.67 | 120.78 | 121.74 | 120.12 | 120.68 | 120.72 | 121.26 | 120.99 | 120.90 |
| 0.33 | 141.15 | 6.79 | 117.06 | 115.57 | 113.95 | 113.59 | 120.40 | 121.53 | 119.90 | 120.47 | 120.02 | 120.82 | 120.55 | 120.53 |
| 0.34 | 142.10 | 5.96 | 117.65 | 116.17 | 114.87 | 114.37 | 121.66 | 122.85 | 121.25 | 121.97 | 120.86 | 122.00 | 122.12 | 121.82 |
| ***Configuration 3*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.30 | 222.15 | 13.47 | 95.20 | 93.83 | 95.65 | 95.17 | 97.89 | 99.18 | 98.77 | 99.01 | 96.45 | 98.00 | 99.01 | |
| 0.33 | 221.96 | 13.18 | 95.29 | 93.92 | 95.89 | 95.33 | 98.35 | 99.60 | 99.26 | 99.48 | 96.72 | 98.31 | 99.43 | |
| 0.35 | 218.81 | 12.55 | 95.33 | 94.00 | 96.00 | 95.44 | 98.67 | 99.92 | 99.56 | 99.72 | 96.84 | 98.42 | 99.67 | |
| 0.35 | 219.88 | 13.73 | 95.61 | 94.20 | 96.13 | 95.47 | 98.88 | 100.23 | 99.74 | 100.04 | 97.19 | 98.60 | 100.00 | |
| 0.37 | 214.85 | 12.94 | 95.79 | 94.40 | 96.34 | 95.61 | 99.64 | 101.04 | 100.55 | 100.80 | 97.64 | 99.06 | 100.65 | |
| 0.45 | 228.44 | 14.33 | 95.46 | 94.21 | 96.04 | 95.28 | 99.27 | 100.70 | 100.14 | 100.45 | 97.38 | 98.93 | 100.33 | |
| 0.50 | 228.14 | 14.05 | 95.35 | 94.09 | 95.98 | 95.24 | 99.25 | 100.74 | 100.19 | 100.52 | 97.28 | 99.00 | 100.37 | |
| 0.55 | 229.75 | 14.02 | 95.68 | 94.49 | 96.27 | 95.50 | 99.69 | 101.17 | 100.55 | 100.90 | 97.71 | 99.38 | 100.72 | |
| 0.60 | 232.04 | 14.14 | 95.56 | 94.46 | 95.83 | 95.26 | 99.72 | 101.07 | 100.33 | 100.69 | 97.63 | 99.23 | 100.51 | |
| **105°F** | | | | | | | | | | | | | | |
| 0.30 | 230.26 | 14.22 | 106.43 | 106.48 | 104.47 | 104.62 | 108.99 | 109.72 | 108.00 | 107.85 | 107.58 | 107.59 | 107.59 | |
| 0.33 | 229.65 | 13.61 | 106.34 | 106.37 | 104.05 | 104.21 | 109.15 | 109.83 | 107.83 | 107.71 | 107.65 | 107.74 | 107.45 | |
| 0.35 | 226.67 | 12.93 | 105.49 | 105.57 | 103.83 | 103.90 | 108.71 | 109.71 | 107.77 | 107.70 | 106.91 | 107.34 | 107.42 | |
| 0.37 | 222.51 | 12.36 | 106.16 | 106.17 | 104.70 | 104.79 | 109.59 | 110.90 | 109.31 | 109.29 | 108.09 | 108.66 | 109.02 | |
| 0.45 | 235.75 | 13.93 | 105.93 | 105.93 | 104.36 | 104.47 | 109.27 | 110.58 | 108.78 | 108.75 | 107.50 | 108.30 | 108.40 | |
| 0.50 | 235.89 | 13.81 | 106.36 | 106.35 | 104.97 | 105.09 | 109.81 | 111.23 | 109.62 | 109.60 | 108.11 | 108.91 | 109.24 | |
| **115°F** | | | | | | | | | | | | | | |
| 0.35 | 238.88 | 14.75 | 115.62 | 116.24 | 115.42 | 114.96 | 119.27 | 120.78 | 119.57 | 119.92 | 117.66 | 118.44 | 119.78 | 119.34 |
| 0.37 | 231.99 | 14.87 | 114.75 | 115.46 | 114.42 | 114.05 | 118.53 | 120.28 | 119.08 | 119.40 | 116.90 | 117.30 | 119.23 | 118.67 |
| 0.37 | 234.21 | 13.85 | 114.92 | 115.69 | 114.86 | 114.37 | 118.97 | 120.73 | 119.51 | 119.88 | 117.25 | 118.21 | 119.70 | 119.18 |

| TE/WT at Temp | CLNT AFT AFT CLR | CLNT B4 PUMP p | CELL AMB T/L | CELL AMB B/L | CELL AMB T/R | CELL AMB B/R | AIR B4 INLET 1 | AIR B4 INLET 2 | AIR B4 INLET 3 | AIR B4 INLET 4 | AIR B4 INLET 5 | AIR B4 INLET 6 | AIR B4 INLET 7 | AVERAGE Air B4 Inlet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0 35 | 116.85 | 12.00 | 95.73 | 97.85 | 93.54 | 93.77 | 98.44 | 99.42 | 98.05 | 98.05 | 97.95 | 98.32 | 97.80 | |
| 0.45 | 117.93 | 14.74 | 95.89 | 98.21 | 93.56 | 93.87 | 98.75 | 99.66 | 98.13 | 98.08 | 98.12 | 98.80 | 97.77 | |
| 0.50 | 117.82 | 14.72 | 95.69 | 97.92 | 93.11 | 93.72 | 98.50 | 99.26 | 97.68 | 97.41 | 97.76 | 98.45 | 96.93 | |
| 0.55 | 118.61 | 13.64 | 95.78 | 97.97 | 93.36 | 93.77 | 98.77 | 99.59 | 98.01 | 97.83 | 98.22 | 99.01 | 97.39 | |
| 0.60 | 118.50 | 12.07 | 95 18 | 97.76 | 93.33 | 93.60 | 98.64 | 99.64 | 98.20 | 97.99 | 97.65 | 98.65 | 97.51 | |
| **105°F** | | | | | | | | | | | | | | |
| 0.26 | 128.73 | 10.12 | 105 47 | 105.33 | 104.20 | 104.44 | 108.58 | 109.13 | 107.84 | 107.60 | 107.26 | 108.08 | 107.15 | |
| 0.31 | 129.43 | 8.18 | 106.16 | 106.28 | 105.03 | 105.20 | 109.87 | 110.61 | 109.32 | 109.15 | 108.41 | 109.43 | 108.70 | |
| 0.32 | 130.01 | 7.69 | 106.22 | 106.31 | 104.86 | 105.08 | 110.04 | 110.84 | 109.54 | 109.32 | 108.53 | 109.52 | 108.80 | |
| 0.33 | 130.06 | 7 15 | 106.17 | 106.19 | 104.79 | 105.03 | 110.13 | 110.99 | 109.75 | 109.48 | 108.58 | 109.70 | 108.86 | |
| 0.35 | 131.10 | 9.01 | 106.18 | 106.24 | 104.69 | 104.77 | 109.95 | 110.74 | 109.35 | 109.08 | 108.43 | 109.80 | 108.62 | |
| 0.40 | 130.11 | 11.86 | 106.70 | 106.22 | 104.11 | 104.35 | 109.79 | 110.46 | 108.88 | 108.77 | 109.14 | 109.69 | 108.46 | |
| 0.45 | 130 71 | 10.81 | 106.94 | 106.31 | 104.03 | 104.31 | 110.01 | 110.59 | 109.02 | 108.88 | 109.40 | 110.10 | 108.72 | |
| 0.50 | 131.05 | 10.07 | 106.86 | 106.39 | 104.25 | 104.47 | 110.23 | 110.82 | 109.26 | 109.25 | 109.42 | 110.28 | 109.00 | |
| 0.55 | 131.33 | 9.63 | 107.10 | 106.77 | 104.42 | 104.58 | 110.44 | 111 21 | 109 56 | 109 46 | 109.62 | 110 61 | 109 22 | |
| 0.60 | 131.82 | 9.64 | 107.27 | 107.05 | 104.82 | 104.86 | 110.95 | 111.67 | 110.00 | 109.92 | 109.92 | 110.87 | 109.65 | |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 141.87 | 8.88 | 118.76 | 118.04 | 116.32 | 116.35 | 122.35 | 123.16 | 121.64 | 121.62 | 121.52 | 122.40 | 121.59 | 122 04 |
| 0.32 | 142.05 | 8.61 | 117.96 | 117.15 | 115.59 | 115.49 | 121.65 | 122.46 | 121.00 | 120.98 | 120.75 | 121.75 | 120.85 | 121.35 |
| 0.33 | 142.01 | 8.39 | 117.07 | 116.28 | 114.90 | 114.73 | 121.14 | 122.01 | 120.61 | 120.69 | 120.05 | 121.31 | 120.66 | 120.92 |
| ***Configuration 2*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.294 | 118.62 | 6.50 | 96.15 | 96.10 | 94.42 | 94.00 | 98.95 | 99.88 | 98.77 | 98.80 | 97.82 | 98.62 | 98.45 | |
| 0.33 | 118.88 | 5.08 | 96.16 | 95.97 | 94.40 | 93 99 | 99.20 | 100.31 | 99.27 | 99.36 | 98.07 | 98.96 | 98.89 | |
| 0.35 | 119.51 | 4.45 | 96.06 | 95.87 | 94.56 | 94.31 | 99.47 | 100.78 | 99.94 | 100.05 | 98.43 | 99.42 | 99.57 | |
| 0.35 | 119 17 | 5.57 | 95.91 | 95.41 | 93.88 | 93.78 | 99.17 | 100.17 | 98.99 | 99.16 | 98.21 | 99.17 | 99 10 | |
| 0.40 | 120.59 | 5 70 | 96.48 | 95.98 | 94.43 | 94.31 | 99.70 | 100.71 | 99.49 | 99.63 | 98.42 | 99.79 | 99.60 | |
| 0.45 | 120.56 | 5.00 | 95.86 | 95.27 | 93.83 | 93.80 | 99.19 | 100.16 | 98.95 | 99.14 | 97.90 | 99.38 | 99.15 | |
| 0.50 | 122.10 | 4.54 | 97.09 | 96.18 | 94.84 | 94 94 | 100.63 | 101.65 | 100.29 | 100.45 | 99.30 | 100.72 | 100.37 | |
| 0.55 | 122.25 | 4.39 | 96.89 | 96.00 | 94.75 | 94 77 | 100.57 | 101.54 | 100.30 | 100 47 | 99.20 | 100.69 | 100.44 | |
| 0.60 | 122.20 | 4.54 | 96.56 | 95.83 | 94.44 | 94 40 | 100.20 | 101.20 | 99.99 | 100.15 | 98.91 | 100.50 | 100.11 | |
| **105°F** | | | | | | | | | | | | | | |
| 0.307 | 129.29 | 7.11 | 106.37 | 105.92 | 104.13 | 103.53 | 109.43 | 110.56 | 109.30 | 109.23 | 108.34 | 109.08 | 108.96 | |
| 0.33 | 130.19 | 5.88 | 106.62 | 106.27 | 104.72 | 104.17 | 110.03 | 111.39 | 110.07 | 110.08 | 108.80 | 109.69 | 109.76 | |
| 0.40 | 131.37 | 6.29 | 106.82 | 106.58 | 104.96 | 104.37 | 110.47 | 111 93 | 110.53 | 110.60 | 109.40 | 110.40 | 110.29 | |
| 0.45 | 130.90 | 5.48 | 106.47 | 106.30 | 104.85 | 104.34 | 110.30 | 111.81 | 110.56 | 110.62 | 109.11 | 110.21 | 110.33 | |
| 0.50 | 130.84 | 5.36 | 105.82 | 105.66 | 104.43 | 103.94 | 109.92 | 111.41 | 110.11 | 110.16 | 108.44 | 109.85 | 109.92 | |
| 0.55 | 131.60 | 5.58 | 106.64 | 106.51 | 105.05 | 104.48 | 110.71 | 112.31 | 110.93 | 111.02 | 109.45 | 110.66 | 110.71 | |
| 0.60 | 130.69 | 6.08 | 105.34 | 105.18 | 103.82 | 103.19 | 109.63 | 111.19 | 109.89 | 109.98 | 108.29 | 109.72 | 109.78 | |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 140.10 | 9.22 | 117.20 | 115.11 | 113.33 | 112.77 | 119.61 | 120.50 | 118.77 | 119.35 | 119.90 | 120 31 | 119.85 | 119.76 |
| 0.32 | 140.94 | 7 72 | 117.72 | 115.91 | 114 17 | 113.67 | 120.78 | 121.74 | 120.12 | 120.68 | 120.72 | 121.26 | 120.99 | 120.90 |
| 0.33 | 141 15 | 6.79 | 117.06 | 115.57 | 113.95 | 113.59 | 120.40 | 121.53 | 119.90 | 120.47 | 120.02 | 120.82 | 120.55 | 120.53 |
| 0.34 | 142.10 | 5.96 | 117.65 | 116.17 | 114.87 | 114.37 | 121.66 | 122.85 | 121.25 | 121.97 | 120.86 | 122.00 | 122.12 | 121.82 |
| ***Configuration 3*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.30 | 222.15 | 13.47 | 95.20 | 93.83 | 95.65 | 95 17 | 97.89 | 99.18 | 98.77 | 99.01 | 96.45 | 98.00 | 99.01 | |
| 0.33 | 221 96 | 13.18 | 95.29 | 93.92 | 95.89 | 95.33 | 98.35 | 99.60 | 99.26 | 99.48 | 96 72 | 98.31 | 99.43 | |
| 0.35 | 218.81 | 12.55 | 95.33 | 94.00 | 96.00 | 95.44 | 98.67 | 99.92 | 99.56 | 99.72 | 96.84 | 98 42 | 99.67 | |
| 0.35 | 219.88 | 13.73 | 95.61 | 94.20 | 96.13 | 95.47 | 98.88 | 100.23 | 99.74 | 100.04 | 97.19 | 98.60 | 100.00 | |
| 0.37 | 214.85 | 12.94 | 95.79 | 94.40 | 96.34 | 95.61 | 99.64 | 101.04 | 100.55 | 100.80 | 97.64 | 99.06 | 100.65 | |
| 0.45 | 228.44 | 14.33 | 95.46 | 94.21 | 96.04 | 95.28 | 99 27 | 100.70 | 100.14 | 100.45 | 97.38 | 98.93 | 100.33 | |
| 0.50 | 228.14 | 14.05 | 95.35 | 94.09 | 95.98 | 95.24 | 99.25 | 100.74 | 100.19 | 100.52 | 97.28 | 99.00 | 100.37 | |
| 0.55 | 229.75 | 14.02 | 95.68 | 94.49 | 96.27 | 95.50 | 99.69 | 101.17 | 100.55 | 100.90 | 97.71 | 99.38 | 100.72 | |
| 0.60 | 232.04 | 14.14 | 95.56 | 94.46 | 95.83 | 95.26 | 99.72 | 101.07 | 100.33 | 100.69 | 97.63 | 99.23 | 100.51 | |
| **105°F** | | | | | | | | | | | | | | |
| 0.30 | 230.26 | 14.22 | 106.43 | 106.48 | 104.47 | 104.62 | 108.99 | 109.72 | 108.00 | 107 85 | 107.58 | 107.59 | 107.59 | |
| 0.33 | 229.65 | 13.61 | 106.34 | 106.37 | 104.05 | 104.21 | 109.15 | 109.83 | 107.83 | 107.71 | 107.65 | 107.74 | 107 45 | |
| 0.35 | 226.67 | 12.93 | 105.49 | 105.57 | 103.83 | 103.90 | 108.71 | 109.71 | 107.77 | 107.70 | 106.91 | 107.34 | 107 42 | |
| 0.37 | 222.51 | 12.36 | 106.16 | 106.17 | 104.70 | 104.79 | 109.59 | 110.90 | 109.31 | 109.29 | 108.09 | 108.66 | 109.02 | |
| 0.45 | 235.75 | 13.93 | 105.93 | 105.93 | 104.36 | 104.47 | 109.27 | 110.58 | 108.78 | 108.75 | 107.50 | 108.30 | 108.40 | |
| 0.50 | 235.89 | 13.81 | 106.36 | 106.35 | 104.97 | 105.09 | 109.81 | 111.23 | 109.62 | 109.60 | 108.11 | 108.91 | 109.24 | |
| **115°F** | | | | | | | | | | | | | | |
| 0.35 | 238.88 | 14.75 | 115.62 | 116.24 | 115.42 | 114.98 | 119.27 | 120.78 | 119.57 | 119.92 | 117.66 | 118.44 | 119.78 | 119.34 |
| 0.37 | 231.99 | 14.87 | 114.75 | 115 46 | 114 42 | 114.05 | 118.53 | 120.28 | 119.08 | 119 40 | 116.90 | 117.30 | 119.23 | 118.67 |
| 0.37 | 234.21 | 13.85 | 114.92 | 115.69 | 114.86 | 114.37 | 118.97 | 120.73 | 119.51 | 119.88 | 117.25 | 118.21 | 119.70 | 119.18 |

| TE/WT at Temp | AIR >FAN R/4 f | AIR B4 RAD 1 f | AIR B4 RAD 2 f | AIR B4 RAD 3 f | AIR B4 RAD 4 f | AIR B4 RAD 5 f | AIR B4 RAD 6 f | AIR B4 RAD 7 f | AIR B4 RAD 8 f | AIR B4 RAD 9 f | AIR B4 RAD 10 f | AVERAGE Air B4 Rad | AIR AFT RAD 1 f | AIR AFT RAD 2 f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.35 | 114.63 | 121.35 | 124.30 | 146.99 | 116.81 | 108.01 | 123.85 | 125.04 | 112.34 | 125.96 | 132.90 | | 160.71 | 174.63 |
| 0.45 | 114.15 | 124.74 | 127.55 | 154.81 | 118.96 | 108.76 | 126.94 | 127.40 | 114.00 | 129.02 | 137.23 | | 169.99 | 185.80 |
| 0.50 | 115.07 | 124.60 | 127.50 | 155.64 | 119.06 | 108.37 | 126.42 | 127.22 | 113.44 | 128.68 | 137.27 | | 171.17 | 187.06 |
| 0.55 | 115.51 | 125.07 | 128.10 | 157.13 | 119.44 | 108.91 | 127.24 | 127.61 | 113.60 | 129.16 | 137.95 | | 173.49 | 189.59 |
| 0.60 | 116.18 | 125.58 | 128.39 | 158.30 | 119.67 | 108.96 | 127.59 | 127.52 | 113.52 | 129.37 | 138.32 | | 175.74 | 191.96 |
| **105°F** | | | | | | | | | | | | | | |
| 0.26 | 129.35 | 136.57 | 138.61 | 165.62 | 129.14 | 124.26 | 142.02 | 141.03 | 127.43 | 140.74 | 150.67 | | 173.37 | 189.81 |
| 0.31 | 128.95 | 135.38 | 137.42 | 163.97 | 128.36 | 122.26 | 139.54 | 139.09 | 126.28 | 139.83 | 148.54 | | 173.93 | 189.24 |
| 0.32 | 128.40 | 135.08 | 136.85 | 163.56 | 128.14 | 120.96 | 137.70 | 138.17 | 125.55 | 139.18 | 147.63 | | 175.14 | 189.96 |
| 0.33 | 127.92 | 134.72 | 136.48 | 163.07 | 127.86 | 121.01 | 137.02 | 137.62 | 125.07 | 138.83 | 147.17 | | 175.57 | 190.06 |
| 0.35 | 129.35 | 137.26 | 139.62 | 170.25 | 129.58 | 121.19 | 140.26 | 139.72 | 126.87 | 141.46 | 151.09 | | 183.98 | 201.06 |
| 0.40 | 128.44 | 134.96 | 137.45 | 165.31 | 128.22 | 120.73 | 138.52 | 138.36 | 125.46 | 139.40 | 147.88 | | 180.31 | 196.14 |
| 0.45 | 129.14 | 135.53 | 137.91 | 166.79 | 128.58 | 121.43 | 139.04 | 138.72 | 125.49 | 139.82 | 148.55 | | 182.08 | 197.81 |
| 0.50 | 129.22 | 136.10 | 138.49 | 168.07 | 128.85 | 122.17 | 139.75 | 138.71 | 125.48 | 140.36 | 148.84 | | 183.84 | 199.37 |
| 0.55 | 129.94 | 136.98 | 139.35 | 170.06 | 129.50 | 122.08 | 140.32 | 139.25 | 125.85 | 140.80 | 149.67 | | 186.38 | 202.00 |
| 0.60 | 130.62 | 137.82 | 140.45 | 172.09 | 130.31 | 122.72 | 141.73 | 139.75 | 126.15 | 141.48 | 150.58 | | 188.94 | 204.75 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 139.37 | 147.95 | 150.43 | 176.43 | 142.24 | 135.17 | 152.68 | 152.44 | 139.14 | 152.80 | 161.23 | 151.05 | 188.36 | 203.44 |
| 0.32 | 138.55 | 146.82 | 149.13 | 175.68 | 141.35 | 132.80 | 150.30 | 150.77 | 137.53 | 151.04 | 159.62 | 149.50 | 189.13 | 203.70 |
| 0.33 | 138.11 | 145.93 | 148.50 | 174.86 | 140.43 | 133.30 | 149.41 | 149.31 | 136.07 | 149.97 | 158.47 | 148.63 | 190.20 | 204.24 |
| ***Configuration 2*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.294 | 121.64 | 123.32 | 125.06 | 153.81 | 115.67 | 118.77 | 131.53 | 127.55 | 120.71 | 132.26 | 140.82 | | 169.36 | 176.63 |
| 0.33 | 122.50 | 121.42 | 123.07 | 152.70 | 115.05 | 116.81 | 129.41 | 125.91 | 118.94 | 129.92 | 138.41 | | 170.39 | 176.73 |
| 0.35 | 122.76 | 120.00 | 121.84 | 151.59 | 114.65 | 116.10 | 128.36 | 125.25 | 118.06 | 128.45 | 137.18 | | 171.69 | 177.22 |
| 0.35 | 122.40 | 118.67 | 121.45 | 149.11 | 112.94 | 115.69 | 125.50 | 125.20 | 118.56 | 127.86 | 136.68 | | 177.30 | 176.40 |
| 0.40 | 125.19 | 122.03 | 124.55 | 156.10 | 114.78 | 117.17 | 128.23 | 127.37 | 121.06 | 130.78 | 141.04 | | 186.97 | 187.02 |
| 0.45 | 124.85 | 120.94 | 123.63 | 155.97 | 114.58 | 115.93 | 127.33 | 126.75 | 120.30 | 129.85 | 140.45 | | 187.61 | 187.21 |
| 0.50 | 126.58 | 121.98 | 125.28 | 157.69 | 116.57 | 117.09 | 128.32 | 128.05 | 121.65 | 131.07 | 142.00 | | 191.72 | 190.59 |
| 0.55 | 127.46 | 122.00 | 125.57 | 159.32 | 117.26 | 116.62 | 128.33 | 128.15 | 121.71 | 131.23 | 142.81 | | 194.44 | 193.24 |
| 0.60 | 127.86 | 121.96 | 125.92 | 160.91 | 117.33 | 116.24 | 128.74 | 128.15 | 121.62 | 131.31 | 143.37 | | 197.43 | 196.49 |
| **105°F** | | | | | | | | | | | | | | |
| 0.307 | 132.11 | 133.30 | 134.73 | 162.30 | 126.65 | 127.15 | 139.13 | 137.64 | 131.57 | 141.77 | 150.78 | | 195.27 | 186.94 |
| 0.33 | 132.73 | 131.93 | 133.07 | 161.89 | 126.35 | 125.68 | 137.24 | 136.48 | 130.22 | 140.22 | 149.32 | | | 188.00 |
| 0.40 | 135.15 | 133.37 | 134.80 | 166.34 | 127.16 | 125.73 | 138.93 | 137.78 | 131.38 | 141.41 | 151.67 | | | 197.66 |
| 0.45 | 134.97 | 132.55 | 134.29 | 166.00 | 126.47 | 124.88 | 138.38 | 137.20 | 130.79 | 140.47 | 150.94 | | | 197.77 |
| 0.50 | 135.35 | 132.18 | 134.29 | 167.04 | 126.51 | 123.87 | 137.88 | 136.85 | 130.41 | 140.10 | 151.16 | | | 199.66 |
| 0.55 | 136.49 | 132.84 | 135.47 | 168.63 | 127.80 | 124.26 | 138.66 | 137.64 | 131.14 | 140.91 | 152.25 | | 189.62 | 202.46 |
| 0.60 | 136.31 | 132.02 | 135.06 | 169.87 | 127.18 | 122.75 | 137.92 | 136.87 | 130.34 | 140.29 | 152.16 | | 191.73 | 205.00 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 143.74 | 142.79 | 145.47 | 172.20 | 136.60 | 138.08 | 152.03 | 149.09 | 142.17 | 152.07 | 161.13 | 149.16 | 186.19 | 197.81 |
| 0.32 | 144.62 | 142.59 | 144.79 | 172.76 | 136.92 | 137.25 | 150.82 | 148.71 | 142.03 | 151.35 | 160.53 | 148.77 | 187.77 | 199.02 |
| 0.33 | 144.38 | 142.06 | 144.31 | 172.22 | 135.87 | 135.54 | 149.16 | 147.83 | 141.05 | 150.15 | 159.55 | 147.77 | 188.26 | 199.41 |
| 0.34 | 145.50 | 142.52 | 145.05 | 172.85 | 137.11 | 135.90 | 149.55 | 148.42 | 141.74 | 150.55 | 159.98 | 148.37 | 189.90 | 201.08 |
| ***Configuration 3*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.30 | 135.44 | 122.74 | 138.83 | 157.26 | 119.53 | 117.35 | 133.63 | 129.72 | 122.88 | 134.77 | 144.15 | | 169.91 | 190.62 |
| 0.33 | 136.01 | 122.59 | 138.76 | 157.75 | 121.18 | 116.60 | 133.04 | 129.28 | 122.48 | 134.71 | 144.00 | | 171.29 | 191.39 |
| 0.35 | 135.70 | 121.54 | 137.74 | 156.62 | 121.94 | 115.70 | 131.76 | 128.33 | 121.61 | 133.33 | 142.79 | | 171.09 | 190.43 |
| 0.35 | 135.87 | 121.67 | 137.79 | 155.50 | 119.49 | 116.10 | 132.55 | 128.92 | 121.94 | 133.42 | 142.83 | | 171.47 | 190.83 |
| 0.37 | 136.07 | 119.84 | 136.63 | 154.69 | 121.39 | 113.87 | 130.60 | 128.47 | 119.86 | 131.45 | 141.11 | | 172.29 | 190.13 |
| 0.45 | 138.58 | 121.81 | 139.72 | 160.22 | 122.42 | 114.32 | 132.47 | 129.86 | 121.44 | 133.38 | 144.15 | | 180.11 | 199.98 |
| 0.50 | 139.03 | 121.36 | 139.69 | 160.67 | 123.15 | 114.09 | 132.24 | 129.76 | 120.82 | 133.04 | 144.02 | | 181.18 | 200.84 |
| 0.55 | 139.92 | 121.49 | 140.49 | 161.81 | 123.96 | 114.11 | 132.64 | 130.29 | 120.90 | 133.06 | 144.47 | | 183.23 | 203.00 |
| 0.60 | 140.34 | 121.46 | 140.91 | 163.13 | 123.95 | 113.59 | 132.69 | 130.43 | 120.70 | 132.87 | 144.84 | | 185.57 | 205.50 |
| **105°F** | | | | | | | | | | | | | | |
| 0.30 | 144.14 | 132.44 | 149.49 | 166.85 | 130.52 | 125.45 | 142.45 | 139.68 | 131.75 | 143.20 | 152.87 | | 179.16 | 200.14 |
| 0.33 | 144.32 | 131.67 | 148.97 | 167.31 | 130.87 | 124.65 | 140.95 | 138.91 | 130.77 | 142.26 | 152.25 | | 180.36 | 200.79 |
| 0.35 | 144.11 | 130.51 | 147.81 | 166.13 | 130.62 | 123.84 | 139.49 | 137.78 | 129.57 | 140.71 | 150.94 | | 180.03 | 199.63 |
| 0.37 | 144.43 | 128.83 | 146.44 | 164.72 | 131.14 | 122.87 | 139.02 | 137.98 | 127.63 | 138.57 | 149.17 | | 181.27 | 199.26 |
| 0.45 | 147.00 | 130.85 | 149.42 | 169.87 | 132.25 | 123.19 | 140.28 | 139.14 | 129.48 | 140.61 | 152.25 | | 189.00 | 209.00 |
| 0.50 | 147.53 | 130.74 | 149.80 | 170.36 | 133.40 | 123.21 | 141.05 | 139.62 | 129.20 | 140.42 | 152.32 | | 190.30 | 210.00 |
| **115°F** | | | | | | | | | | | | | | |
| 0.35 | 156.66 | 142.18 | 156.47 | 176.20 | 139.43 | 139.09 | 153.22 | 149.46 | 143.74 | 153.95 | 163.13 | 151.69 | 192.94 | 211.39 |
| 0.37 | 154.45 | 138.16 | 153.32 | 170.95 | 138.54 | 135.45 | 149.46 | 147.16 | 139.46 | 150.16 | 159.05 | 146.17 | 191.09 | 208.25 |
| 0.37 | 156.45 | 139.91 | 154.94 | 174.61 | 139.36 | 136.64 | 150.90 | 148.48 | 140.60 | 151.37 | 160.97 | 149.77 | 193.61 | 210.62 |

| TE/WT at Temp | AIR AFT RAD 3 f | AIR AFT RAD 4 f | AIR AFT RAD 5 f | AIR AFT RAD 6 f | AIR AFT RAD 7 f | AIR AFT RAD 8 f | AIR AFT RAD 9 f | AIR AFT RAD 10 f | AIR B4 EX GR 1 | AIR B4 EX GR 2 | AIR B4 EX GR 3 | AIR B4 EX GR 4 | AIR B4 EX GR 5 | AIR B4 EX GR 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.35 | 163.35 | 145.00 | 144.29 | 154.92 | 150.21 | | 154.96 | 164.00 | 154.80 | 161.86 | 173.78 | 165.47 | 169.70 | 175.60 |
| 0.45 | 173.25 | 152.39 | 151.54 | 163.54 | 158.71 | | 163.68 | 174.37 | 162.95 | 170.79 | 184.65 | 174.92 | 179.76 | 186.44 |
| 0.50 | 174.41 | 153.41 | 152.56 | 164.56 | 159.33 | | 164.76 | 175.44 | 164.16 | 172.04 | 186.04 | 176.20 | 181.24 | 187.99 |
| 0.55 | 176.61 | 155.33 | 154.76 | 166.66 | 161.24 | | 166.94 | 177.74 | 166.33 | 174.31 | 188.53 | 178.51 | 183.87 | 190.60 |
| 0.60 | 178.65 | 156.87 | 156.45 | 168.31 | 162.80 | | 168.72 | 179.76 | 168.34 | 175.95 | 190.71 | 180.43 | 186.07 | 192.84 |
| **105°F** | | | | | | | | | | | | | | |
| 0.26 | 177.38 | 155.59 | 153.30 | 165.38 | 160.56 | 160.04 | 166.83 | 178.29 | 167.71 | 174.01 | 189.14 | 178.90 | 180.38 | 188.43 |
| 0.31 | 176.66 | 155.85 | 153.91 | 165.85 | 160.69 | 160.35 | 166.61 | 177.16 | 167.92 | 174.41 | 187.89 | 178.74 | 181.26 | 188.44 |
| 0.32 | 177.15 | 156.71 | 155.17 | 166.71 | 161.70 | 161.26 | 167.33 | 177.52 | 168.88 | 175.50 | 188.35 | 179.56 | 182.69 | 189.71 |
| 0.33 | 177.20 | 157.01 | 155.86 | 167.06 | 162.05 | 161.69 | 167.60 | 177.41 | 169.33 | 175.96 | 188.40 | 179.86 | 183.33 | 190.08 |
| 0.35 | 186.75 | 163.91 | 162.52 | 175.20 | 170.02 | 169.41 | 176.01 | 187.99 | 177.00 | 184.22 | 199.23 | 189.07 | 193.07 | 200.48 |
| 0.40 | 180.25 | 160.74 | 161.25 | 171.54 | 167.48 | 165.93 | 172.11 | 183.56 | 173.35 | 180.93 | 194.80 | 185.34 | 189.46 | 196.64 |
| 0.45 | 181.86 | 162.10 | 163.00 | 173.08 | 168.96 | 167.37 | 173.60 | 184.97 | 174.93 | 182.63 | 196.47 | 186.95 | 191.39 | 198.57 |
| 0.50 | 183.32 | 163.23 | 164.42 | 174.19 | 170.18 | 168.55 | 174.88 | 186.18 | 176.35 | 184.21 | 197.99 | 188.48 | 193.10 | 200.19 |
| 0.55 | 185.45 | 165.11 | 166.52 | 176.40 | 171.90 | 170.69 | 176.97 | 188.50 | 178.56 | 186.56 | 200.60 | 190.90 | 195.77 | 202.90 |
| 0.60 | 187.96 | 167.25 | 168.82 | 178.59 | 173.78 | 172.90 | 179.34 | 191.08 | 181.03 | 189.05 | 203.43 | 193.55 | 198.74 | 205.88 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 188.40 | 168.29 | 166.38 | 178.31 | 173.53 | 171.88 | 178.56 | 188.00 | 182.39 | 188.91 | 202.11 | 193.13 | 196.44 | 203.24 |
| 0.32 | 188.59 | 168.88 | 167.30 | 178.84 | 174.20 | 172.50 | 178.92 | 188.08 | 182.99 | 189.70 | 202.32 | 193.67 | 197.59 | 204.13 |
| 0.33 | 188.88 | 169.38 | 168.79 | 179.30 | 174.81 | 173.11 | 179.53 | 188.25 | 183.73 | 190.51 | 202.77 | 194.41 | 198.81 | 205.04 |
| ***Configuration 2*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.294 | 168.00 | 146.21 | 147.61 | 155.97 | 150.41 | 153.58 | 157.21 | 167.48 | 156.95 | 162.17 | 178.35 | 169.05 | 168.68 | 180.55 |
| 0.33 | 167.89 | 147.33 | 149.14 | 156.76 | 150.93 | 154.21 | 157.53 | 167.40 | 157.90 | 163.26 | 177.66 | 169.51 | 170.49 | 181.58 |
| 0.35 | 168.00 | 148.20 | 150.87 | 157.48 | 151.99 | 155.09 | 158.23 | 167.57 | 159.59 | 164.41 | 177.82 | 170.37 | 172.25 | 182.79 |
| 0.35 | 166.82 | 146.67 | 150.04 | 155.66 | 151.50 | 154.84 | 157.60 | 167.20 | 158.86 | 163.35 | 177.30 | 169.91 | 171.51 | 182.42 |
| 0.40 | 176.30 | 153.77 | 157.57 | 163.97 | 159.37 | 163.03 | 166.05 | 177.20 | 167.05 | 171.95 | 187.89 | 179.43 | 181.50 | 193.05 |
| 0.45 | 176.58 | 154.34 | 158.18 | 164.16 | 159.86 | 163.36 | 166.26 | 177.32 | 167.41 | 172.17 | 187.83 | 179.45 | 181.80 | 193.26 |
| 0.50 | 179.14 | 157.22 | 161.27 | 166.94 | 162.79 | 166.19 | 169.05 | 180.03 | 170.62 | 175.76 | 191.01 | 182.83 | 185.50 | 196.99 |
| 0.55 | 181.44 | 159.42 | 163.57 | 169.20 | 165.05 | 168.37 | 171.25 | 182.45 | 172.82 | 178.25 | 193.62 | 185.39 | 188.24 | 199.75 |
| 0.60 | 184.20 | 161.63 | 166.20 | 172.27 | 167.68 | 170.96 | 173.90 | 185.38 | 175.45 | 181.03 | 196.77 | 188.49 | 191.48 | 203.11 |
| **105°F** | | | | | | | | | | | | | | |
| 0.307 | 176.18 | 156.00 | 156.67 | 164.29 | 158.77 | 162.94 | 165.90 | 176.46 | 167.55 | 172.87 | 188.15 | 179.49 | 179.57 | 191.58 |
| 0.33 | 176.93 | 157.36 | 159.03 | 165.10 | 160.37 | 164.10 | 167.05 | 177.08 | 169.61 | 174.60 | 188.62 | 180.75 | 181.89 | 193.47 |
| 0.40 | 184.95 | 163.85 | 166.60 | 173.29 | 168.03 | 171.75 | 174.71 | 185.64 | 177.97 | 182.80 | 198.11 | 189.73 | 191.92 | 203.69 |
| 0.45 | 185.10 | 164.27 | 167.08 | 173.77 | 168.47 | 172.13 | 174.90 | 185.60 | 178.31 | 183.08 | 197.99 | 189.91 | 192.30 | 203.95 |
| 0.50 | 186.64 | 165.70 | 168.63 | 175.55 | 170.18 | 173.57 | 176.27 | 187.28 | 179.81 | 184.91 | 199.87 | 191.75 | 194.53 | 205.99 |
| 0.55 | 188.87 | 168.02 | 170.91 | 177.98 | 172.54 | 175.82 | 178.50 | 189.65 | 182.22 | 187.67 | 202.58 | 194.46 | 197.45 | 208.86 |
| 0.60 | 191.02 | 169.64 | 172.88 | 180.33 | 174.51 | 177.82 | 180.41 | 192.02 | 184.13 | 189.70 | 205.00 | 196.86 | 200.11 | 211.65 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 184.56 | 164.98 | 165.17 | 173.08 | 167.71 | 171.59 | 174.33 | 184.88 | 178.36 | 183.75 | 199.16 | 190.66 | 191.01 | 202.88 |
| 0.32 | 185.59 | 166.41 | 167.18 | 174.58 | 169.17 | 172.94 | 175.43 | 185.66 | 180.24 | 185.41 | 199.67 | 191.75 | 192.91 | 204.45 |
| 0.33 | 185.88 | 166.55 | 168.01 | 175.24 | 169.81 | 173.46 | 175.78 | 185.75 | 181.13 | 185.89 | 199.79 | 192.22 | 193.78 | 205.16 |
| 0.34 | 187.00 | 168.08 | 169.70 | 176.96 | 171.44 | 174.98 | 177.02 | 186.75 | 182.93 | 187.75 | 201.12 | 193.90 | 195.93 | 206.89 |
| ***Configuration 3*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.30 | 176.00 | 157.20 | 148.93 | 162.45 | 156.52 | 162.00 | 168.85 | 163.92 | 169.24 | 171.63 | 190.14 | 181.99 | 170.37 | 187.00 |
| 0.33 | 176.91 | 158.76 | 149.98 | 163.57 | 157.66 | 163.08 | 169.84 | 164.59 | 169.70 | 173.22 | 190.80 | 183.16 | 171.75 | 188.31 |
| 0.35 | 176.34 | 158.91 | 150.07 | 163.53 | 157.58 | 162.63 | 169.12 | 163.96 | 169.15 | 173.50 | 189.55 | 182.66 | 171.85 | 187.81 |
| 0.35 | 176.52 | 158.66 | 150.83 | 164.42 | 158.43 | 163.46 | 169.73 | 163.79 | 169.80 | 173.58 | 189.93 | 183.10 | 172.51 | 188.31 |
| 0.37 | 176.17 | 159.74 | 152.14 | 165.38 | 159.21 | 163.02 | 169.13 | 163.48 | 170.59 | 175.02 | 188.79 | 183.34 | 174.11 | 188.89 |
| 0.45 | 184.62 | 166.57 | 158.36 | 172.69 | 166.30 | 170.34 | 177.15 | 170.66 | 178.30 | 182.77 | 198.78 | 192.54 | 182.06 | 198.39 |
| 0.50 | 185.38 | 167.65 | 159.56 | 173.79 | 167.27 | 171.05 | 177.84 | 171.42 | 179.36 | 184.00 | 199.48 | 193.59 | 183.46 | 199.58 |
| 0.55 | 187.14 | 169.36 | 161.35 | 175.75 | 169.04 | 172.60 | 179.38 | 172.86 | 181.33 | 186.10 | 201.32 | 195.67 | 185.88 | 201.88 |
| 0.60 | 189.24 | 171.13 | 163.38 | 177.94 | 171.15 | 174.49 | 181.30 | 174.70 | 183.54 | 188.56 | 203.77 | 198.17 | 188.48 | 204.66 |
| **105°F** | | | | | | | | | | | | | | |
| 0.30 | 183.35 | 165.13 | 155.76 | 169.73 | 164.00 | 168.18 | 175.71 | 171.40 | 177.84 | 181.65 | 199.44 | 191.75 | 179.77 | 196.47 |
| 0.33 | 184.32 | 166.44 | 157.06 | 170.91 | 165.29 | 169.22 | 176.49 | 171.74 | 178.38 | 182.95 | 199.85 | 192.78 | 181.27 | 197.74 |
| 0.35 | 183.54 | 166.01 | 157.11 | 170.70 | 165.01 | 168.70 | 175.67 | 171.18 | 177.84 | 182.71 | 198.37 | 191.94 | 181.15 | 197.17 |
| 0.37 | 183.27 | 166.81 | 159.09 | 172.51 | 166.41 | 168.73 | 175.41 | 170.91 | 179.13 | 184.53 | 197.78 | 192.48 | 183.64 | 198.49 |
| 0.45 | 191.40 | 173.48 | 165.19 | 179.36 | 173.26 | 176.11 | 183.32 | 177.70 | 186.51 | 192.13 | 207.52 | 201.62 | 191.34 | 207.85 |
| 0.50 | 192.36 | 174.84 | 166.72 | 180.99 | 174.49 | 176.96 | 184.22 | 178.59 | 187.97 | 193.69 | 208.48 | 202.85 | 193.21 | 209.33 |
| **115°F** | | | | | | | | | | | | | | |
| 0.35 | 193.03 | 175.53 | 168.44 | 181.95 | 175.22 | 181.22 | 186.08 | 180.20 | 189.76 | 194.83 | 210.90 | 204.25 | 194.23 | 210.00 |
| 0.37 | 190.07 | 174.10 | 168.08 | 180.86 | 174.22 | 178.77 | 183.76 | 177.68 | 188.23 | 193.50 | 207.52 | 202.03 | 193.77 | 208.10 |
| 0.37 | 192.66 | 175.96 | 170.04 | 182.93 | 176.14 | 180.74 | 185.70 | 179.89 | 190.37 | 195.71 | 209.82 | 204.35 | 195.89 | 210.48 |

| TE/WT at Temp | AIR AFT EX GR 1 | AIR AFT EX GR 2 | AIR AFT EX GR 3 | AIR AFT EX GR 4 | AIR AFT EX GR 5 | AIR AFT EX GR 6 | AIR B4 IN GR p1 | AIR B4 IN GR p2 | AIR B4 IN GR p3 | AIR B4 IN GR p4 | AIR B4 IN GR p5 | AIR B4 IN GR p6 | AIR B4 IN GR p7 | AIR AFT IN GR p1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.35 | 164.00 | 166.95 | 176.31 | 170.54 | 167.82 | 179.43 | -0.18 | -0.44 | -0.32 | -0.40 | -0.21 | -0.23 | -0.30 | -0.79 |
| 0.45 | 173.05 | 176.25 | 187.03 | 180.28 | 177.14 | 190.38 | -0.17 | -0.45 | -0.26 | -0.41 | -0.22 | -0.24 | -0.32 | -0.83 |
| 0.50 | 174.26 | 177.55 | 188.30 | 181.53 | 178.53 | 191.81 | -0.16 | -0.44 | -0.25 | -0.40 | -0.21 | -0.23 | -0.30 | -0.78 |
| 0.55 | 176.45 | 179.93 | 190.85 | 183.95 | 181.17 | 194.47 | -0.15 | -0.44 | -0.23 | -0.39 | -0.21 | -0.23 | -0.29 | -0.76 |
| 0.60 | 178.71 | 181.90 | 193.09 | 186.01 | 183.46 | 196.81 | -0.14 | -0.43 | -0.23 | -0.39 | -0.21 | -0.23 | -0.29 | -0.75 |
| **105°F** | | | | | | | | | | | | | | |
| 0.26 | 177.83 | 178.19 | 191.49 | 184.70 | 178.30 | 192.35 | -0.33 | -0.63 | -0.35 | -0.56 | -0.31 | -0.34 | -0.46 | -1.39 |
| 0.31 | 177.90 | 179.14 | 190.76 | 184.54 | 179.32 | 192.60 | -0.21 | -0.54 | -0.23 | -0.46 | -0.26 | -0.28 | -0.34 | -1.06 |
| 0.32 | 178.71 | 180.48 | 191.33 | 185.25 | 180.81 | 193.75 | -0.15 | -0.51 | -0.22 | -0.41 | -0.24 | -0.26 | -0.29 | -0.91 |
| 0.33 | 179.06 | 181.11 | 191.51 | 185.63 | 181.66 | 194.27 | -0.12 | -0.49 | -0.17 | -0.39 | -0.23 | -0.25 | -0.26 | -0.84 |
| 0.35 | 187.62 | 189.64 | 202.05 | 195.10 | 190.36 | 204.75 | -0.16 | -0.52 | -0.12 | -0.42 | -0.24 | -0.26 | -0.30 | -0.94 |
| 0.40 | 183.17 | 185.45 | 197.24 | 190.86 | 186.98 | 200.56 | -0.13 | -0.50 | -0.11 | -0.40 | -0.24 | -0.26 | -0.28 | -0.91 |
| 0.45 | 184.81 | 187.34 | 198.74 | 192.26 | 188.89 | 202.40 | -0.12 | -0.49 | -0.11 | -0.39 | -0.23 | -0.25 | -0.26 | -0.86 |
| 0.50 | 186.25 | 188.97 | 200.21 | 193.66 | 190.48 | 203.94 | -0.10 | -0.48 | -0.11 | -0.38 | -0.22 | -0.24 | -0.25 | -0.83 |
| 0.55 | 188.49 | 191.51 | 202.80 | 196.15 | 193.07 | 206.68 | -0.09 | -0.47 | -0.10 | -0.37 | -0.22 | -0.24 | -0.24 | -0.80 |
| 0.60 | 190.95 | 194.05 | 205.56 | 198.74 | 195.84 | 209.58 | -0.09 | -0.47 | -0.10 | -0.37 | -0.22 | -0.24 | -0.23 | -0.78 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 192.46 | 194.06 | 205.15 | 198.81 | 195.09 | 207.41 | -0.14 | -0.58 | -0.03 | -0.43 | -0.29 | -0.27 | -0.30 | -1.08 |
| 0.32 | 193.05 | 195.30 | 205.48 | 199.44 | 196.29 | 208.38 | -0.09 | -0.54 | -0.03 | -0.38 | -0.27 | -0.25 | -0.24 | -0.95 |
| 0.33 | 193.63 | 196.38 | 205.97 | 200.07 | 197.72 | 209.32 | -0.05 | -0.52 | -0.03 | -0.35 | -0.25 | -0.23 | -0.21 | -0.83 |
| ***Configuration 2*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.294 | 165.35 | 165.75 | 180.14 | 174.07 | 168.06 | 181.00 | -0.29 | -0.59 | -0.35 | -0.51 | -0.25 | -0.27 | -0.41 | -1.23 |
| 0.33 | 166.43 | 167.56 | 179.89 | 174.73 | 169.54 | 182.32 | -0.19 | -0.51 | -0.32 | -0.42 | -0.21 | -0.22 | -0.32 | -0.90 |
| 0.35 | 167.89 | 168.91 | 180.28 | 175.62 | 171.36 | 183.67 | -0.14 | -0.47 | -0.26 | -0.37 | -0.19 | -0.19 | -0.27 | -0.72 |
| 0.35 | 167.33 | 168.18 | 179.66 | 175.01 | 171.06 | 183.26 | -0.14 | -0.46 | -0.21 | -0.37 | -0.19 | -0.19 | -0.28 | -0.76 |
| 0.40 | 175.97 | 176.77 | 190.01 | 184.70 | 180.24 | 193.77 | -0.15 | -0.47 | -0.20 | -0.37 | -0.19 | -0.19 | -0.28 | -0.77 |
| 0.45 | 176.52 | 177.45 | 190.21 | 185.07 | 180.78 | 194.23 | -0.14 | -0.46 | -0.20 | -0.36 | -0.18 | -0.19 | -0.27 | -0.71 |
| 0.50 | 179.50 | 180.83 | 193.35 | 188.25 | 184.44 | 197.68 | -0.12 | -0.45 | -0.21 | -0.34 | -0.18 | -0.17 | -0.25 | -0.66 |
| 0.55 | 181.79 | 183.63 | 196.08 | 190.92 | 187.32 | 200.65 | -0.11 | -0.45 | -0.20 | -0.34 | -0.18 | -0.17 | -0.24 | -0.64 |
| 0.60 | 184.49 | 186.44 | 199.06 | 193.96 | 190.41 | 203.90 | -0.10 | -0.44 | -0.19 | -0.33 | -0.17 | -0.17 | -0.23 | -0.62 |
| **105°F** | | | | | | | | | | | | | | |
| 0.307 | 176.48 | 177.15 | 190.74 | 185.03 | 179.47 | 192.43 | -0.22 | -0.61 | -0.22 | -0.48 | -0.26 | -0.27 | -0.34 | -1.16 |
| 0.33 | 178.60 | 179.41 | 191.53 | 186.39 | 181.89 | 194.51 | -0.13 | -0.55 | -0.18 | -0.40 | -0.23 | -0.22 | -0.27 | -0.89 |
| 0.40 | 187.11 | 187.85 | 200.75 | 195.47 | 191.10 | 204.62 | -0.10 | -0.53 | -0.09 | -0.37 | -0.21 | -0.21 | -0.24 | -0.81 |
| 0.45 | 187.66 | 188.53 | 200.86 | 195.86 | 191.93 | 205.11 | -0.08 | -0.51 | -0.09 | -0.36 | -0.20 | -0.20 | -0.22 | -0.75 |
| 0.50 | 189.00 | 190.42 | 202.55 | 197.59 | 193.78 | 207.07 | -0.06 | -0.50 | -0.05 | -0.34 | -0.20 | -0.19 | -0.21 | -0.71 |
| 0.55 | 191.40 | 193.08 | 205.11 | 200.23 | 196.69 | 209.94 | -0.05 | -0.50 | -0.05 | -0.34 | -0.20 | -0.19 | -0.20 | -0.69 |
| 0.60 | 193.40 | 195.20 | 207.55 | 202.81 | 199.26 | 212.63 | -0.05 | -0.49 | -0.05 | -0.33 | -0.19 | -0.19 | -0.20 | -0.66 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 187.13 | 187.74 | 201.48 | 195.91 | 190.84 | 203.42 | -0.17 | -0.64 | -0.09 | -0.46 | -0.28 | -0.28 | -0.32 | -1.19 |
| 0.32 | 189.13 | 189.92 | 202.34 | 197.24 | 192.95 | 205.21 | -0.11 | -0.59 | -0.09 | -0.40 | -0.25 | -0.25 | -0.26 | -0.99 |
| 0.33 | 190.11 | 190.64 | 202.64 | 197.86 | 193.82 | 205.99 | -0.07 | -0.56 | -0.05 | -0.37 | -0.24 | -0.23 | -0.23 | -0.89 |
| 0.34 | 191.82 | 192.65 | 204.07 | 199.58 | 196.09 | 207.85 | -0.04 | -0.54 | 0.00 | -0.34 | -0.23 | -0.22 | -0.20 | -0.82 |
| ***Configuration 3*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.30 | 175.80 | 172.97 | 194.17 | 187.90 | 174.72 | 191.05 | -0.25 | -0.63 | -0.38 | -0.49 | -0.26 | -0.26 | -0.42 | -1.25 |
| 0.33 | 176.48 | 174.58 | 195.02 | 189.18 | 176.30 | 192.37 | -0.21 | -0.59 | -0.35 | -0.45 | -0.24 | -0.23 | -0.37 | -1.11 |
| 0.35 | 176.05 | 174.89 | 193.91 | 188.67 | 176.48 | 191.95 | -0.16 | -0.55 | -0.35 | -0.40 | -0.22 | -0.20 | -0.33 | -0.96 |
| 0.35 | 177.17 | 175.37 | 194.61 | 189.40 | 177.43 | 192.90 | -0.15 | -0.55 | -0.28 | -0.40 | -0.22 | -0.20 | -0.32 | -0.96 |
| 0.37 | 177.92 | 177.20 | 193.75 | 189.56 | 179.04 | 193.48 | -0.08 | -0.49 | -0.23 | -0.33 | -0.18 | -0.15 | -0.24 | -0.71 |
| 0.45 | 185.85 | 184.60 | 203.60 | 198.90 | 186.65 | 202.97 | -0.09 | -0.50 | -0.19 | -0.34 | -0.19 | -0.16 | -0.25 | -0.77 |
| 0.50 | 186.78 | 185.93 | 204.33 | 199.75 | 188.08 | 204.11 | -0.08 | -0.49 | -0.17 | -0.33 | -0.18 | -0.15 | -0.24 | -0.70 |
| 0.55 | 188.60 | 188.09 | 206.19 | 201.90 | 190.28 | 206.39 | -0.07 | -0.48 | -0.17 | -0.32 | -0.18 | -0.15 | -0.22 | -0.67 |
| 0.60 | 190.77 | 190.47 | 208.55 | 204.34 | 192.71 | 209.05 | -0.06 | -0.47 | -0.14 | -0.31 | -0.17 | -0.14 | -0.21 | -0.63 |
| **105°F** | | | | | | | | | | | | | | |
| 0.30 | 184.00 | 182.50 | 202.95 | 197.37 | 183.06 | 200.37 | -0.20 | -0.69 | -0.27 | -0.51 | -0.29 | -0.28 | -0.37 | -1.30 |
| 0.33 | 184.67 | 183.95 | 203.57 | 198.35 | 184.77 | 201.60 | -0.15 | -0.64 | -0.23 | -0.45 | -0.27 | -0.25 | -0.31 | -1.12 |
| 0.35 | 184.48 | 183.99 | 202.39 | 197.68 | 184.76 | 201.05 | -0.10 | -0.61 | -0.16 | -0.41 | -0.25 | -0.22 | -0.27 | -0.99 |
| 0.37 | 185.59 | 186.23 | 202.03 | 198.11 | 187.29 | 202.40 | -0.05 | -0.55 | -0.03 | -0.34 | -0.21 | -0.18 | -0.20 | -0.75 |
| 0.45 | 193.21 | 193.47 | 211.61 | 207.35 | 194.91 | 211.81 | -0.05 | -0.56 | -0.06 | -0.35 | -0.21 | -0.19 | -0.21 | -0.80 |
| 0.50 | 194.52 | 195.18 | 212.56 | 208.58 | 196.64 | 213.32 | -0.05 | -0.54 | -0.06 | -0.34 | -0.21 | -0.18 | -0.20 | -0.75 |
| **115°F** | | | | | | | | | | | | | | |
| 0.35 | 196.91 | 196.57 | 215.70 | 210.39 | 197.47 | 214.20 | -0.05 | -0.62 | 0.05 | -0.38 | -0.24 | -0.22 | -0.21 | -0.99 |
| 0.37 | 195.23 | 195.82 | 212.65 | 207.91 | 197.34 | 212.43 | 0.00 | -0.56 | 0.05 | -0.32 | -0.22 | -0.19 | -0.15 | -0.79 |
| 0.37 | 197.54 | 197.91 | 214.93 | 210.25 | 199.46 | 214.72 | 0.01 | -0.56 | 0.05 | -0.32 | -0.22 | -0.18 | -0.15 | -0.77 |

| TE/WT at Temp | AIR AFT IN GR p2 | AIR AFT IN GR p3 | AIR AFT IN GR p4 | AIR AFT IN GR p5 | AIR AFT IN GR p6 | AIR AFT IN GR p7 | AIR AFT IN TP1 | AIR AFT IN TP2 | AIR AFT IN TP3 | AIR AFT IN TP4 | AIR AFT IN TP5 | AIR AFT IN TP6 | AIR AFT IN TP7 | AIR B4 FAN L/p1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.35 | -0.83 | -1.33 | -0.81 | -0.45 | -0.56 | -1.16 | -0.45 | -0.43 | -0.77 | -1.38 | -0.32 | -0.28 | -0.62 | -2.66 |
| 0.45 | -0.89 | -1.43 | -0.88 | -0.47 | -0.62 | -1.24 | -0.50 | -0.43 | -0.83 | -1.47 | -0.33 | -0.30 | -0.68 | -2.84 |
| 0.50 | -0.83 | -1.33 | -0.82 | -0.44 | -0.60 | -1.16 | -0.46 | -0.43 | -0.77 | -1.41 | -0.32 | -0.29 | -0.64 | -2.66 |
| 0.55 | -0.79 | -1.28 | -0.77 | -0.42 | -0.59 | -1.12 | -0.44 | -0.43 | -0.74 | -1.38 | -0.31 | -0.28 | -0.62 | -2.56 |
| 0.60 | -0.76 | -1.24 | -0.75 | -0.41 | -0.59 | -1.10 | -0.43 | -0.41 | -0.71 | -1.35 | -0.29 | -0.27 | -0.60 | -2.48 |
| **105°F** | | | | | | | | | | | | | | |
| 0.28 | -1.65 | -2.71 | -1.75 | -0.86 | -1.13 | -2.21 | -0.94 | -0.60 | -1.60 | -2.40 | -0.60 | -0.52 | -1.00 | -5.47 |
| 0.31 | -1.17 | -1.89 | -1.20 | -0.59 | -0.88 | -1.62 | -0.68 | -0.49 | -1.09 | -1.83 | -0.42 | -0.40 | -0.77 | -3.95 |
| 0.32 | -0.96 | -1.54 | -0.96 | -0.47 | -0.77 | -1.35 | -0.57 | -0.47 | -0.87 | -1.57 | -0.36 | -0.35 | -0.68 | -3.31 |
| 0.33 | -0.84 | -1.36 | -0.83 | -0.41 | -0.72 | -1.22 | -0.51 | -0.44 | -0.76 | -1.44 | -0.32 | -0.33 | -0.58 | -2.96 |
| 0.35 | -0.99 | -1.59 | -0.99 | -0.49 | -0.82 | -1.39 | -0.60 | -0.49 | -0.91 | -1.60 | -0.37 | -0.36 | -0.69 | -3.40 |
| 0.40 | -0.92 | -1.48 | -0.92 | -0.49 | -0.67 | -1.31 | -0.56 | -0.48 | -0.83 | -1.57 | -0.36 | -0.35 | -0.65 | -3.19 |
| 0.45 | -0.85 | -1.36 | -0.84 | -0.44 | -0.63 | -1.21 | -0.53 | -0.48 | -0.75 | -1.47 | -0.33 | -0.34 | -0.61 | -2.97 |
| 0.50 | -0.80 | -1.30 | -0.79 | -0.42 | -0.60 | -1.16 | -0.50 | -0.48 | -0.71 | -1.43 | -0.32 | -0.33 | -0.59 | -2.83 |
| 0.55 | -0.77 | -1.24 | -0.75 | -0.40 | -0.58 | -1.12 | -0.48 | -0.47 | -0.68 | -1.40 | -0.31 | -0.33 | -0.57 | -2.74 |
| 0.60 | -0.75 | -1.20 | -0.72 | -0.39 | -0.56 | -1.09 | -0.48 | -0.46 | -0.65 | -1.37 | -0.31 | -0.32 | -0.56 | -2.67 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | -1.16 | -1.81 | -1.16 | -0.53 | -0.98 | -1.58 | -0.68 | -0.55 | -1.00 | -1.81 | -0.40 | -0.46 | -0.81 | -3.56 |
| 0.32 | -0.95 | -1.47 | -0.92 | -0.41 | -0.87 | -1.33 | -0.58 | -0.53 | -0.77 | -1.56 | -0.33 | -0.41 | -0.70 | -2.93 |
| 0.33 | -0.79 | -1.22 | -0.74 | -0.32 | -0.78 | -1.13 | -0.51 | -0.51 | -0.62 | -1.38 | -0.28 | -0.37 | -0.63 | -2.46 |
| ***Configuration 2*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.294 | -1.44 | -2.38 | -1.50 | -0.83 | -0.80 | -1.84 | | -0.58 | -1.35 | -2.03 | -0.56 | -0.62 | -1.15 | -5.34 |
| 0.33 | -1.00 | -1.66 | -1.00 | -0.59 | -0.58 | -1.33 | | -0.48 | -0.92 | -1.58 | -0.40 | -0.45 | -0.77 | -3.87 |
| 0.35 | -0.76 | -1.26 | -0.72 | -0.46 | -0.46 | -1.03 | | -0.41 | -0.69 | -1.30 | -0.32 | -0.36 | -0.55 | -3.03 |
| 0.35 | -0.79 | -1.28 | -0.74 | -0.46 | -0.47 | -1.05 | | -0.43 | -0.70 | -1.32 | -0.33 | -0.40 | -0.52 | -3.07 |
| 0.40 | -0.83 | -1.35 | -0.78 | -0.49 | -0.52 | -1.10 | | -0.43 | -0.74 | -1.37 | -0.34 | -0.40 | -0.54 | -3.21 |
| 0.45 | -0.74 | -1.22 | -0.69 | -0.44 | -0.48 | -0.99 | | -0.42 | -0.66 | -1.29 | -0.32 | -0.37 | -0.50 | -2.94 |
| 0.50 | -0.67 | -1.09 | -0.61 | -0.40 | -0.47 | -0.91 | | -0.38 | -0.60 | -1.19 | -0.28 | -0.34 | -0.45 | -2.68 |
| 0.55 | -0.62 | -1.03 | -0.56 | -0.37 | -0.47 | -0.87 | | -0.38 | -0.56 | -1.16 | -0.27 | -0.33 | -0.42 | -2.54 |
| 0.60 | -0.59 | -0.98 | -0.52 | -0.35 | -0.45 | -0.81 | | -0.37 | -0.52 | -1.12 | -0.27 | -0.32 | -0.41 | -2.44 |
| **105°F** | | | | | | | | | | | | | | |
| 0.307 | -1.30 | -2.13 | -1.34 | -0.74 | -0.86 | -1.70 | | -0.56 | -1.16 | -1.91 | -0.52 | -0.63 | -0.95 | -4.82 |
| 0.33 | -0.94 | -1.55 | -0.94 | -0.54 | -0.70 | -1.28 | | -0.50 | -0.83 | -1.52 | -0.38 | -0.49 | -0.67 | -3.62 |
| 0.40 | -0.81 | -1.33 | -0.79 | -0.47 | -0.64 | -1.11 | | -0.45 | -0.69 | -1.38 | -0.34 | -0.44 | -0.58 | -3.16 |
| 0.45 | -0.72 | -1.19 | -0.69 | -0.42 | -0.59 | -1.01 | | -0.44 | -0.62 | -1.29 | -0.31 | -0.41 | -0.54 | -2.87 |
| 0.50 | -0.67 | -1.10 | -0.63 | -0.39 | -0.57 | -0.96 | | -0.42 | -0.57 | -1.24 | -0.29 | -0.39 | -0.49 | -2.70 |
| 0.55 | -0.62 | -1.04 | -0.59 | -0.37 | -0.56 | -0.90 | | -0.42 | -0.53 | -1.19 | -0.28 | -0.38 | -0.49 | -2.56 |
| 0.60 | -0.59 | -0.98 | -0.56 | -0.34 | -0.54 | -0.86 | | -0.42 | -0.50 | -1.16 | -0.26 | -0.36 | -0.47 | -2.44 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | -1.32 | -2.15 | -1.37 | -0.75 | -0.88 | -1.74 | | -0.63 | -1.18 | -1.96 | -0.51 | -0.70 | -0.95 | -4.81 |
| 0.32 | -1.04 | -1.69 | -1.05 | -0.59 | -0.75 | -1.40 | | -0.57 | -0.89 | -1.68 | -0.41 | -0.59 | -0.76 | -3.85 |
| 0.33 | -0.89 | -1.43 | -0.87 | -0.50 | -0.68 | -1.22 | | -0.52 | -0.73 | -1.52 | -0.37 | -0.53 | -0.67 | -3.34 |
| 0.34 | -0.77 | -1.24 | -0.74 | -0.43 | -0.64 | -1.09 | | -0.50 | -0.62 | -1.40 | -0.33 | -0.49 | -0.61 | -2.94 |
| ***Configuration 3*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.30 | -1.52 | -2.67 | -1.63 | -0.86 | -1.08 | -1.95 | -0.41 | -0.66 | -1.73 | -1.66 | -0.57 | 0.10 | -1.19 | -5.65 |
| 0.33 | -1.31 | -2.29 | -1.38 | -0.75 | -0.97 | -1.70 | -0.38 | -0.58 | -1.47 | -1.47 | -0.49 | 0.18 | -1.02 | -4.91 |
| 0.35 | -1.09 | -1.90 | -1.13 | -0.63 | -0.87 | -1.43 | -0.33 | -0.53 | -1.20 | -1.29 | -0.40 | 0.26 | -0.85 | -4.15 |
| 0.35 | -1.11 | -1.91 | -1.13 | -0.62 | -0.90 | -1.45 | -0.32 | -0.54 | -1.21 | -1.31 | -0.42 | 0.25 | -0.86 | -4.18 |
| 0.37 | -0.74 | -1.28 | -0.71 | -0.41 | -0.71 | -1.03 | -0.25 | -0.46 | -0.75 | -0.99 | -0.31 | 0.36 | -0.56 | -2.96 |
| 0.45 | -0.82 | -1.41 | -0.81 | -0.46 | -0.76 | -1.11 | -0.26 | -0.48 | -0.83 | -1.06 | -0.32 | 0.33 | -0.62 | -3.21 |
| 0.50 | -0.73 | -1.26 | -0.70 | -0.41 | -0.71 | -1.01 | -0.24 | -0.45 | -0.73 | -0.99 | -0.29 | 0.36 | -0.55 | -2.92 |
| 0.55 | -0.68 | -1.17 | -0.64 | -0.37 | -0.69 | -0.95 | -0.23 | -0.44 | -0.66 | -0.95 | -0.27 | 0.39 | -0.52 | -2.74 |
| 0.60 | -0.63 | -1.09 | -0.59 | -0.35 | -0.65 | -0.90 | -0.23 | -0.42 | -0.60 | -0.91 | -0.26 | 0.41 | -0.48 | -2.59 |
| **105°F** | | | | | | | | | | | | | | |
| 0.30 | -1.54 | -2.71 | -1.68 | -0.87 | -1.05 | -2.00 | -0.40 | -0.66 | -1.66 | -1.68 | -0.58 | 0.09 | -1.29 | -5.71 |
| 0.33 | -1.27 | -2.22 | -1.36 | -0.71 | -0.93 | -1.69 | -0.26 | -0.61 | -1.32 | -1.44 | -0.47 | 0.18 | -1.06 | -4.76 |
| 0.35 | -1.07 | -1.88 | -1.13 | -0.61 | -0.84 | -1.45 | -0.22 | -0.56 | -1.09 | -1.29 | -0.42 | 0.25 | -0.90 | -4.10 |
| 0.37 | -0.73 | -1.29 | -0.73 | -0.42 | -0.67 | -1.05 | -0.22 | -0.48 | -0.68 | -0.99 | -0.29 | 0.36 | -0.59 | -2.94 |
| 0.45 | -0.81 | -1.41 | -0.81 | -0.45 | -0.73 | -1.14 | -0.29 | -0.48 | -0.76 | -1.07 | -0.32 | 0.32 | -0.67 | -3.18 |
| 0.50 | -0.73 | -1.28 | -0.72 | -0.41 | -0.69 | -1.05 | -0.30 | -0.47 | -0.68 | -1.01 | -0.30 | 0.35 | -0.60 | -2.92 |
| **115°F** | | | | | | | | | | | | | | |
| 0.35 | -1.03 | -1.75 | -1.04 | -0.54 | -0.90 | -1.39 | -0.37 | -0.59 | -1.01 | -1.30 | -0.40 | 0.14 | -0.83 | -3.96 |
| 0.37 | -0.73 | -1.23 | -0.70 | -0.37 | -0.74 | -1.04 | -0.34 | -0.52 | -0.64 | -1.06 | -0.30 | 0.25 | -0.60 | -2.90 |
| 0.37 | -0.71 | -1.20 | -0.67 | -0.36 | -0.74 | -1.02 | -0.34 | -0.52 | -0.60 | -1.05 | -0.29 | 0.25 | -0.59 | -2.83 |

| TE/WT at Temp | AIR B4 FAN L/p2 | AIR B4 FAN L/p3 | AIR B4 FAN L/p4 | AIR B4 FAN R/p1 | AIR B4 FAN R/p2 | AIR B4 FAN R/p3 | AIR B4 FAN R/p4 | AIR B4 FAN LTP1 | AIR B4 FAN LTP2 | AIR B4 FAN LTP3 | AIR B4 FAN LTP4 | AIR B4 FAN RTP1 | AIR B4 FAN RTP2 | AIR B4 FAN RTP3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.35 | -2.72 | -3.39 | -2.36 | -3.36 | -2.44 | -3.66 | -2.86 | -1.12 | -1.69 | -1.63 | -0.96 | -1.13 | -0.78 | -1.11 |
| 0.45 | -2.92 | -3.61 | -2.48 | -3.58 | -2.58 | -3.99 | -3.05 | -1.17 | -1.78 | -1.72 | -1.02 | -1.20 | -0.84 | -1.16 |
| 0.50 | -2.74 | -3.39 | -2.35 | -3.35 | -2.43 | -3.75 | -2.86 | -1.11 | -1.69 | -1.64 | -0.97 | -1.13 | -0.79 | -1.11 |
| 0.55 | -2.63 | -3.26 | -2.29 | -3.22 | -2.35 | -3.61 | -2.75 | -1.09 | -1.64 | -1.60 | -0.94 | -1.10 | -0.78 | -1.08 |
| 0.60 | -2.56 | -3.17 | -2.23 | -3.14 | -2.29 | -3.53 | -2.68 | -1.06 | -1.61 | -1.55 | -0.92 | -1.06 | -0.75 | -1.06 |
| **105°F** | | | | | | | | | | | | | | |
| 0.26 | -5.38 | -6.80 | -4.02 | -6.28 | -4.65 | -7.42 | -5.75 | -1.63 | -2.98 | -2.58 | -1.67 | -1.96 | -1.34 | -1.73 |
| 0.31 | -3.85 | -4.86 | -3.00 | -4.55 | -3.36 | -5.27 | -4.16 | -1.28 | -2.18 | -1.89 | -1.23 | -1.44 | -1.04 | -1.35 |
| 0.32 | -3.18 | -4.02 | -2.58 | -3.78 | -2.81 | -4.23 | -3.45 | -1.11 | -1.85 | -1.58 | -1.05 | -1.21 | -0.89 | -1.18 |
| 0.33 | -2.83 | -3.59 | -2.35 | -3.39 | -2.52 | -3.85 | -3.03 | -1.03 | -1.67 | -1.41 | -0.96 | -1.08 | -0.81 | -1.09 |
| 0.35 | -3.28 | -4.12 | -2.64 | -3.91 | -2.88 | -4.46 | -3.55 | -1.13 | -1.89 | -1.64 | -1.08 | -1.24 | -0.90 | -1.20 |
| 0.40 | -3.07 | -3.87 | -2.51 | -3.64 | -2.71 | -4.15 | -3.31 | -1.15 | -1.79 | -1.59 | -1.04 | -1.18 | -0.87 | -1.16 |
| 0.45 | -2.85 | -3.59 | -2.36 | -3.37 | -2.54 | -3.88 | -3.06 | -1.08 | -1.68 | -1.45 | -0.98 | -1.09 | -0.80 | -1.11 |
| 0.50 | -2.71 | -3.42 | -2.27 | -3.20 | -2.42 | -3.61 | -2.91 | -1.05 | -1.61 | -1.37 | -0.95 | -1.04 | -0.78 | -1.09 |
| 0.55 | -2.61 | -3.29 | -2.21 | -3.08 | -2.34 | -3.49 | -2.79 | -1.02 | -1.56 | -1.32 | -0.92 | -1.00 | -0.74 | -1.06 |
| 0.60 | -2.53 | -3.19 | -2.16 | -2.99 | -2.29 | -3.41 | -2.72 | -1.00 | -1.51 | -1.29 | -0.90 | -0.97 | -0.74 | -1.05 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | -3.70 | -4.59 | -2.92 | -4.31 | -3.25 | -4.89 | -3.86 | -1.14 | -2.02 | -1.90 | -1.26 | -1.30 | -1.01 | -1.35 |
| 0.32 | -3.04 | -3.79 | -2.50 | -3.54 | -2.71 | -3.96 | -3.13 | -0.98 | -1.70 | -1.57 | -1.07 | -1.07 | -0.88 | -1.17 |
| 0.33 | -2.56 | -3.21 | -2.19 | -2.97 | -2.33 | -3.40 | -2.61 | -0.86 | -1.45 | -1.32 | -0.94 | -0.89 | -0.75 | -1.05 |
| ***Configuration 2*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.294 | -4.92 | -6.94 | -3.58 | -5.55 | -4.04 | -6.61 | -4.93 | -1.69 | -2.82 | -2.77 | -1.52 | -1.82 | -1.15 | -1.58 |
| 0.33 | -3.50 | -4.98 | -2.68 | -4.05 | -2.94 | -4.69 | -3.51 | -1.36 | -2.17 | -2.08 | -1.14 | -1.34 | -0.91 | -1.27 |
| 0.35 | -2.69 | -3.85 | -2.19 | -3.18 | -2.34 | -3.51 | -2.70 | -1.17 | -1.78 | -1.72 | -0.93 | -1.07 | -0.75 | -1.08 |
| 0.35 | -2.69 | -3.90 | -2.25 | -3.19 | -2.60 | -3.54 | -2.74 | -1.15 | -1.79 | -1.71 | -0.94 | -1.06 | -0.67 | -1.11 |
| 0.40 | -2.82 | -4.06 | -2.34 | -3.36 | -2.68 | -3.78 | -2.87 | -1.18 | -1.85 | -1.79 | -0.96 | -1.11 | -0.70 | -1.14 |
| 0.45 | -2.56 | -3.68 | -2.17 | -3.05 | -2.50 | -3.46 | -2.61 | -1.13 | -1.73 | -1.64 | -0.90 | -1.01 | -0.65 | -1.07 |
| 0.50 | -2.33 | -3.35 | -2.01 | -2.79 | -2.31 | -3.12 | -2.37 | -1.07 | -1.61 | -1.52 | -0.83 | -0.94 | -0.61 | -1.01 |
| 0.55 | -2.21 | -3.16 | -1.93 | -2.64 | -2.20 | -2.93 | -2.23 | -1.03 | -1.54 | -1.43 | -0.79 | -0.89 | -0.59 | -0.98 |
| 0.60 | -2.11 | -3.01 | -1.86 | -2.52 | -2.08 | -2.82 | -2.13 | -1.01 | -1.48 | -1.37 | -0.76 | -0.84 | -0.59 | -0.95 |
| **105°F** | | | | | | | | | | | | | | |
| 0.307 | -4.33 | -6.27 | -3.25 | -5.09 | -3.93 | -5.80 | -4.42 | -1.49 | -2.62 | -2.46 | -1.42 | -1.61 | -0.93 | -1.46 |
| 0.33 | -3.24 | -4.64 | -2.55 | -3.82 | -3.08 | -4.15 | -3.29 | -1.22 | -2.06 | -1.87 | -1.12 | -1.23 | -0.77 | -1.22 |
| 0.40 | -2.80 | -4.01 | -2.29 | -3.34 | -2.61 | -3.64 | -2.85 | -1.12 | -1.84 | -1.66 | -0.99 | -1.08 | -0.76 | -1.12 |
| 0.45 | -2.53 | -3.62 | -2.12 | -3.01 | -2.35 | -3.36 | -2.57 | -1.05 | -1.73 | -1.49 | -0.91 | -0.99 | -0.72 | -1.06 |
| 0.50 | -2.38 | -3.39 | -2.01 | -2.83 | -2.25 | -3.07 | -2.40 | -1.01 | -1.65 | -1.40 | -0.87 | -0.93 | -0.68 | -1.01 |
| 0.55 | -2.26 | -3.22 | -1.93 | -2.68 | -2.13 | -2.89 | -2.28 | -0.97 | -1.58 | -1.32 | -0.83 | -0.88 | -0.65 | -0.99 |
| 0.60 | -2.15 | -3.06 | -1.87 | -2.56 | -1.99 | -2.78 | -2.16 | -0.95 | -1.53 | -1.27 | -0.80 | -0.84 | -0.67 | -0.96 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | -4.37 | -6.24 | -3.22 | -5.02 | -3.83 | -5.80 | -4.48 | -1.46 | -2.61 | -2.46 | -1.46 | -1.55 | -1.17 | -1.46 |
| 0.32 | -3.48 | -4.96 | -2.68 | -4.02 | -3.08 | -4.51 | -3.57 | -1.23 | -2.11 | -1.99 | -1.20 | -1.24 | -1.08 | -1.26 |
| 0.33 | -3.00 | -4.27 | -2.39 | -3.48 | -2.69 | -3.95 | -3.07 | -1.12 | -1.87 | -1.72 | -1.07 | -1.08 | -0.97 | -1.16 |
| 0.34 | -2.63 | -3.75 | -2.16 | -3.04 | -2.38 | -3.43 | -2.63 | -1.04 | -1.68 | -1.54 | -0.98 | -0.95 | -0.87 | -1.08 |
| ***Configuration 3*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.30 | -5.20 | -7.45 | -3.50 | -6.04 | -4.69 | -6.93 | | -1.69 | -7.38 | -5.68 | -1.55 | -1.75 | -1.64 | -2.02 |
| 0.33 | -4.48 | -6.40 | -3.07 | -5.27 | -4.01 | -5.88 | | -1.54 | -6.51 | -4.93 | -1.36 | -1.53 | -1.37 | -1.79 |
| 0.35 | -3.76 | -5.36 | -2.65 | -4.47 | -3.33 | -4.94 | | -1.35 | -5.45 | -4.14 | -1.17 | -1.31 | -1.24 | -1.57 |
| 0.35 | -3.79 | -5.41 | -2.69 | -4.47 | -3.35 | -4.96 | | -1.36 | -5.51 | -4.16 | -1.16 | -1.32 | -1.26 | -1.58 |
| 0.37 | -2.65 | -3.81 | -2.01 | -3.18 | -2.28 | -3.50 | | -1.08 | -3.85 | -2.89 | -0.86 | -0.95 | -0.97 | -1.23 |
| 0.45 | -2.88 | -4.14 | -2.14 | -3.46 | -2.50 | -3.97 | | -1.13 | -4.16 | -3.15 | -0.92 | -1.02 | -1.02 | -1.29 |
| 0.50 | -2.61 | -3.75 | -1.99 | -3.15 | -2.25 | -3.58 | | -1.06 | -3.77 | -2.85 | -0.85 | -0.94 | -0.93 | -1.20 |
| 0.55 | -2.43 | -3.50 | -1.89 | -2.94 | -2.08 | -3.34 | | -1.02 | -3.51 | -2.66 | -0.81 | -0.88 | -0.90 | -1.16 |
| 0.60 | -2.29 | -3.30 | -1.81 | -2.79 | -1.95 | -3.14 | | -0.99 | -3.31 | -2.50 | -0.77 | -0.83 | -0.87 | -1.11 |
| **105°F** | | | | | | | | | | | | | | |
| 0.30 | -5.15 | -3.73 | -3.54 | -6.20 | -4.77 | -7.02 | | -1.68 | -6.59 | -6.21 | -1.58 | -1.79 | -2.48 | -2.17 |
| 0.33 | -4.28 | -3.80 | -3.01 | -5.17 | -3.91 | -5.82 | | -1.46 | -5.50 | -5.08 | -1.34 | -1.50 | -2.09 | -1.83 |
| 0.35 | -3.67 | -4.43 | -2.65 | -4.45 | -3.31 | -4.87 | | -1.31 | -4.78 | -4.31 | -1.20 | -1.30 | -1.87 | -1.61 |
| 0.37 | -2.59 | -2.90 | -2.01 | -3.19 | -2.25 | -3.43 | | -1.04 | -3.47 | -3.00 | -0.90 | -0.94 | -1.39 | -1.25 |
| 0.45 | -2.80 | -3.85 | -2.14 | -3.43 | -2.49 | -3.83 | | -1.10 | -3.78 | -3.26 | -0.96 | -1.01 | -1.52 | -1.32 |
| 0.50 | -2.57 | -3.69 | -2.01 | -3.16 | -2.26 | -3.53 | | -1.03 | -3.56 | -2.97 | -0.90 | -0.92 | -1.38 | -1.24 |
| **115°F** | | | | | | | | | | | | | | |
| 0.35 | -3.56 | -5.18 | -2.55 | -4.10 | -3.13 | -4.72 | | -1.19 | -4.87 | -5.03 | -1.14 | -1.14 | -1.24 | -1.45 |
| 0.37 | -2.61 | -3.81 | -1.97 | -3.00 | -2.23 | -3.46 | | -0.96 | -3.56 | -3.29 | -0.88 | -0.83 | -1.00 | -1.16 |
| 0.37 | -2.54 | -3.66 | -1.95 | -2.92 | -2.16 | -3.31 | | -0.92 | -3.41 | -3.39 | -0.88 | -0.79 | -0.98 | -1.14 |

| TE/WT at Temp | AIR B4 FAN RTP4 | DUCER RACK F | SURGE TANK PSI | Clnt>Rad 1 | Clnt>Rad 2 | Clnt>Rad Average | ClntRad> 1 | ClntRad> 2 | ClntRad> 3 | ClntRad> Average | Clnt>Pmp 1 | Clnt>Pmp 2 | Clnt>Pmp 3 | Clnt>Pmp 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.35 | -2.06 | 81.60 | 10.08 | 194.12 | 193.66 | 193.89 | 179.66 | 179.87 | 180.74 | 180.09 | 180.88 | 180.42 | 180.81 | 181.22 |
| 0.45 | -2.14 | 81.64 | 12.61 | 208.77 | 208.27 | 208.52 | 192.21 | 192.39 | 193.37 | 192.65 | 193.52 | 193.10 | 193.46 | 193.86 |
| 0.50 | -2.04 | 81.51 | 12.63 | 210.24 | 209.61 | 209.92 | 193.30 | 193.49 | 194.46 | 193.75 | 194.61 | 194 17 | 194.54 | 194.93 |
| 0.55 | -1.96 | 81.47 | 11.90 | 213.12 | 212.38 | 212.75 | 195.72 | 195.94 | 196.91 | 196.19 | 197.06 | 196.62 | 197.01 | 197 39 |
| 0.60 | -1.92 | 81.61 | 10.86 | 215.95 | 215.11 | 215.53 | 198.02 | 198.27 | 199.26 | 198.52 | 199.39 | 198.98 | 199.35 | 199.71 |
| **105°F** | | | | | | | | | | | | | | |
| 0.26 | -4.21 | 86.27 | 9.03 | 212.65 | 212.60 | 212.62 | 199.21 | 199.54 | 200.53 | 199.76 | 200.61 | 200.16 | 200.65 | 200.96 |
| 0.31 | -2.99 | 85.37 | 7.86 | 209.85 | 209.72 | 209.78 | 196.27 | 196.57 | 197.54 | 196.79 | 197.64 | 197 11 | 197.66 | 197.97 |
| 0.32 | -2.47 | 85.82 | 7.60 | 209.67 | 209.43 | 209.55 | 195.76 | 196.04 | 197.00 | 196.27 | 197.08 | 196.78 | 197.13 | 197.44 |
| 0.33 | -2.20 | 85.94 | 7.21 | 209.19 | 208.87 | 209.03 | 195.15 | 195.44 | 196.41 | 195.67 | 196.48 | 196.32 | 196.52 | 196.82 |
| 0.35 | -2.53 | 86.55 | 8.13 | 224.51 | 224.16 | 224.33 | 208.42 | 208.76 | 209.77 | 208.98 | 209.90 | 209.49 | 209.94 | 210.23 |
| 0.40 | -2.41 | 88.40 | 10.16 | 219.05 | 218.69 | 218.87 | 203.20 | 203.47 | 204.58 | 203.75 | 204.72 | 205.00 | 204.69 | 205.05 |
| 0.45 | -2.24 | 88.32 | 9.53 | 220.40 | 219.90 | 220.15 | 204.34 | 204.58 | 205.71 | 204.87 | 205.80 | 205.78 | 205.78 | 206.14 |
| 0.50 | -2.14 | 87.80 | 9.09 | 221.90 | 221.24 | 221.57 | 205.60 | 205.81 | 206.87 | 206.09 | 207.04 | 207.25 | 207.02 | 207.37 |
| 0.55 | -2.06 | 88.10 | 8.84 | 224.98 | 224.29 | 224.63 | 208.18 | 208.39 | 209.45 | 208.67 | 209.61 | 209.94 | 209.59 | 209.94 |
| 0.60 | -2.01 | 87.72 | 8.85 | 228.27 | 227.46 | 227.86 | 210.98 | 211.16 | 212.23 | 211.46 | 212.43 | 212.60 | 212.38 | 212.75 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | -2.83 | 93.35 | 8.56 | 222.97 | 222.76 | 222.86 | 209.05 | 209.38 | 210.37 | 209.60 | 210.42 | 210.00 | 210.44 | 210.79 |
| 0.32 | -2.34 | 93.41 | 8.41 | 222.50 | 222.20 | 222.35 | 208.20 | 208.53 | 209.40 | 208.71 | 209.55 | 209.12 | 209.58 | 209.94 |
| 0.33 | -2.00 | 93.38 | 8.27 | 222.24 | 221.61 | 221.92 | 207.58 | 207.89 | 208.76 | 208.07 | 208.91 | 208.63 | 208.92 | 209.28 |
| ***Configuration 2*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.294 | -3.68 | 81.94 | 6.83 | 201.63 | 201.60 | 201.61 | 188.34 | 188.60 | 189.81 | 188.92 | | 190.09 | 189.63 | 190.33 |
| 0.33 | -2.62 | 81.57 | 5.37 | 199.94 | 199.82 | 199.88 | 186.17 | 186.44 | 187.66 | 186.76 | | 187.89 | 187.45 | 188.09 |
| 0.35 | -2.07 | 81.57 | 4.57 | 199.07 | 198.89 | 198.98 | 184.98 | 185.24 | 186.44 | 185.56 | | 186.67 | 186.25 | 186.90 |
| 0.35 | -2.15 | 81.34 | 5.62 | 198.55 | 198.36 | 198.46 | 184.57 | 184.85 | 186.07 | 185 16 | | 186.26 | 185.88 | 186.49 |
| 0.40 | -2.23 | 81.09 | 5.76 | 212.25 | 211.85 | 212.05 | 196.33 | 196.61 | 197.86 | 196.93 | | 198.18 | 197.77 | 198.37 |
| 0.45 | -2.04 | 80.98 | 5.22 | 211.84 | 211 44 | 211.64 | 195.75 | 196.03 | 197.26 | 196.35 | | 197.57 | 197.17 | 197.76 |
| 0.50 | -1.88 | 81.39 | 4.87 | 214.87 | 214.40 | 214.63 | 198.33 | 198.59 | 199.85 | 198.92 | | 200.15 | 199.75 | 200.33 |
| 0.55 | -1.79 | 81.77 | 4.76 | 217.86 | 217.32 | 217.59 | 200.73 | 201.01 | 202.28 | 201.34 | | 202.55 | 202.17 | 202.74 |
| 0.60 | -1.71 | 81.74 | 4.83 | 221.72 | 221.11 | 221.41 | 203.81 | 204.10 | 205.38 | 204.43 | | 205.65 | 205.28 | 205.87 |
| **105°F** | | | | | | | | | | | | | | |
| 0.307 | -3.46 | 86.10 | 7 04 | 210.59 | 210.55 | 210.57 | 197 12 | 197.46 | 198.69 | 197.76 | | 198.96 | 198.60 | 199.22 |
| 0.33 | -2.60 | 85.86 | 5.88 | 210.14 | 209.93 | 210.03 | 196.22 | 196.52 | 197.69 | 196.81 | | 198.01 | 197.66 | 198.26 |
| 0.40 | -2.28 | 86.01 | 5.99 | 221.92 | 221.62 | 221.77 | 205.94 | 206.24 | 207.50 | 206.56 | | 207.82 | 207.45 | 208.03 |
| 0.45 | -2.07 | 86.04 | 5.36 | 221.40 | 221.08 | 221.24 | 205.24 | 205.56 | 206.78 | 205.86 | | 207 10 | 206.73 | 207.31 |
| 0.50 | -1.95 | 86.64 | 5.25 | 223.29 | 223.08 | 223.19 | 206.65 | 206.97 | 208.19 | 207.27 | | 208.50 | 208.13 | 208.71 |
| 0.55 | -1.87 | 86.98 | 5.38 | 226.13 | 225.93 | 226.03 | 209.00 | 209.35 | 210.56 | 209.64 | | 210.88 | 210.50 | 211.09 |
| 0.60 | -1.80 | 87.02 | 5.73 | 229.38 | 229.17 | 229.27 | 211.40 | 211.77 | 213.03 | 212.07 | | 213.34 | 212.94 | 213.57 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | -3.58 | 91.98 | 8.82 | 220.43 | 219.70 | 220.06 | 207.15 | 207.48 | 208.69 | 207.77 | | 209.01 | 208.63 | 209.27 |
| 0.32 | -2.88 | 92.45 | 7.22 | 220.37 | 219.69 | 220.03 | 206.72 | 207.04 | 208.22 | 207.33 | | 208.56 | 208.16 | 208.79 |
| 0.33 | -2.52 | 92.30 | 6.26 | 219.88 | 219.28 | 219.58 | 206.02 | 206.30 | 207 44 | 206.59 | | 207.78 | 207.39 | 208.04 |
| 0.34 | -2.15 | 92.91 | 5.23 | 220.56 | 219.98 | 220.27 | 206.50 | 206.76 | 207.88 | 207.04 | | 208.20 | 207.81 | 208.46 |
| ***Configuration 3*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.30 | -5.23 | 82.28 | 12.67 | 213.52 | 212.20 | 212.86 | 199.93 | 200.39 | 201.38 | 200.57 | 201.87 | | 202.21 | 202.30 |
| 0.33 | -4.53 | 82.10 | 12.24 | 213.65 | 212.33 | 212.99 | 199.69 | 200.20 | 201.24 | 200.38 | 201.61 | | 202.09 | 202.15 |
| 0 35 | -3.84 | 82.05 | 11.33 | 211.26 | 210.01 | 210.64 | 197 31 | 197.73 | 198.73 | 197.93 | 199.12 | | 199.31 | 199.68 |
| 0.35 | -3.84 | 82.62 | 13.05 | 211.93 | 210.77 | 211 35 | 198.27 | 198.43 | 199.49 | 198.73 | 199.84 | | 200.22 | 200.52 |
| 0.37 | -2.77 | 82.19 | 11.88 | 208.71 | 207.58 | 208.14 | 194.77 | 194 94 | 195.85 | 195.19 | 196.31 | | 196.57 | 197.01 |
| 0.45 | -2.98 | 81.78 | 13.70 | 222.05 | 220.58 | 221.32 | 206.41 | 206.55 | 207.62 | 206.86 | 208.11 | | 208.49 | 208.75 |
| 0.50 | -2.74 | 81.88 | 13.32 | 222.36 | 220.89 | 221.62 | 206.49 | 206.56 | 207.58 | 206.88 | 208.10 | | 208.52 | 208.77 |
| 0.55 | -2.55 | 81.84 | 13.28 | 224.38 | 222.85 | 223.62 | 208.12 | 208.21 | 209.25 | 208.52 | 209.78 | | 210.11 | 210.44 |
| 0.60 | -2.42 | 82.00 | 13.43 | 227.24 | 225.62 | 226.43 | 210.37 | 210.44 | 211.52 | 210.78 | 212.10 | | 212.48 | 212.71 |
| **105°F** | | | | | | | | | | | | | | |
| 0.30 | -5.33 | 86.63 | 13.61 | 221.82 | 220.35 | 221.09 | 208.27 | 208.84 | 209.88 | 209.00 | 210.30 | | 210.38 | 210 76 |
| 0.33 | -4.45 | 86.39 | 12 85 | 221.50 | 220.09 | 220.80 | 207.72 | 208.09 | 209.21 | 208.34 | 209.52 | | 209.74 | 210.05 |
| 0.35 | -3.85 | 86 65 | 11.85 | 219.23 | 217.91 | 218.57 | 205.39 | 205.76 | 206.79 | 205.98 | 207.16 | | 207.32 | 207 67 |
| 0.37 | -2.83 | 86.90 | 10.92 | 216.63 | 215.50 | 216.07 | 202.54 | 202.87 | 203.80 | 203.07 | 204.31 | | 204.44 | 204.74 |
| 0.45 | -3.03 | 87.37 | 13.26 | 229.73 | 228.25 | 228.99 | 213.88 | 214.26 | 215.29 | 214 47 | 215 78 | | 216.01 | 216.23 |
| 0.50 | -2.80 | 87 15 | 13.02 | 230.35 | 228.88 | 229.62 | 214.32 | 214.63 | 215 65 | 214.87 | 216.24 | | 216.42 | 216.63 |
| **115°F** | | | | | | | | | | | | | | |
| 0.35 | -3.66 | 95.67 | 13.97 | 230.13 | 229.56 | 229.85 | 217.15 | 217.27 | 218.30 | 217.57 | 218.80 | | 219.89 | 219.38 |
| 0.37 | -2.76 | 95.73 | 13.94 | 225.02 | 224.58 | 224 80 | 211.77 | 211.86 | 212.89 | 212.17 | 213.38 | | 213.69 | 214.01 |
| 0.37 | -2.67 | 95.88 | 12.76 | 227.66 | 226.79 | 227 22 | 213.84 | 213.96 | 214.92 | 214.24 | 215.45 | | 216.08 | 216.08 |
| | | | | | | calculated | | | | calculated | | | | |

| TE/WT at Temp | Ex>Turbo °F | ExTurbo> °F | Oil FD L | Oil FD R | AirComp> psi | Air>Rad 1 H2O | Air>Rad 2 H2O | Air>Rad 3 H2O | Air>Rad 4 H2O | Air>Rad 5 H2O | Air>Rad 6 H2O | Air>Rad 7 H2O | Air>Rad 8 H2O | Air>Rad 9 H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.35 | 1037.65 | 875.13 | 181.09 | 191.25 | 15.74 | 5.07 | 4.06 | 4.68 | 5.00 | 4.90 | 5.09 | 4.58 | 4.43 | 3.75 |
| 0.45 | 1054.46 | 886.90 | 206.00 | 227.34 | 16.41 | 5.45 | 4.41 | 5.03 | 5.38 | 5.28 | 5.51 | 4.97 | 4.79 | 4.05 |
| 0.50 | 1049.00 | 885.06 | 212.96 | 236.58 | 15.91 | 5.14 | 4.16 | 4.74 | 5.07 | 4.99 | 5.19 | 4.69 | 4.51 | 3.82 |
| 0.55 | 1048.03 | 885.67 | 218.18 | 244.00 | 15.60 | 4.96 | 4.01 | 4.58 | 4.91 | 4.83 | 5.00 | 4.53 | 4.36 | 3.70 |
| 0.60 | 1047.16 | 885.93 | 222.33 | 248.16 | 15.41 | 4.87 | 3.93 | 4.48 | 4.80 | 4.72 | 4.87 | 4.43 | 4.27 | 3.62 |
| **105°F** | | | | | | | | | | | | | | |
| 0.26 | 1145.73 | 941.00 | 175.00 | 177.13 | 21.04 | 9.31 | 7.50 | 8.60 | 9.27 | 9.14 | 9.56 | 8.62 | 8.25 | 6.83 |
| 0.31 | 1106.97 | 920.69 | 189.76 | 194.78 | 18.12 | 6.82 | 5.47 | 6.26 | 6.72 | 6.65 | 6.83 | 6.25 | 6.01 | 5.02 |
| 0.32 | 1084.11 | 910.77 | 196.22 | 201.54 | 16.57 | 5.70 | 4.57 | 5.23 | 5.63 | 5.53 | 5.66 | 5.22 | 5.05 | 4.21 |
| 0.33 | 1071.90 | 905.55 | 198.87 | 204.78 | 15.71 | 5.11 | 4.10 | 4.68 | 5.06 | 4.97 | 5.06 | 4.67 | 4.53 | 3.78 |
| 0.35 | 1094.52 | 917.44 | 205.31 | 207.80 | 16.88 | 5.95 | 4.77 | 5.47 | 5.89 | 5.77 | 5.94 | 5.45 | 5.27 | 4.41 |
| 0.40 | 1069.15 | 900.15 | 181.40 | 192.79 | 16.36 | 5.56 | 4.47 | 5.08 | 5.51 | 5.37 | 5.52 | 5.08 | 4.94 | 4.12 |
| 0.45 | 1064.99 | 899.59 | 196.90 | 215.25 | 15.77 | 5.18 | 4.15 | 4.74 | 5.14 | 5.03 | 5.13 | 4.73 | 4.61 | 3.84 |
| 0.50 | 1060.68 | 898.66 | 208.56 | 226.90 | 15.33 | 4.94 | 3.95 | 4.51 | 4.90 | 4.81 | 4.89 | 4.51 | 4.40 | 3.67 |
| 0.55 | 1060.18 | 899.85 | 219.77 | 235.86 | 15.03 | 4.79 | 3.83 | 4.37 | 4.75 | 4.66 | 4.72 | 4.36 | 4.27 | 3.56 |
| 0.60 | 1059.48 | 900.46 | 226.38 | 243.81 | 14.79 | 4.69 | 3.74 | 4.27 | 4.64 | 4.57 | 4.60 | 4.27 | 4.18 | 3.48 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 1131.17 | 944.68 | 208.47 | 201.75 | 17.69 | 6.53 | 5.20 | 6.00 | 6.49 | 6.30 | 6.58 | 5.96 | 5.79 | 4.76 |
| 0.32 | 1107.58 | 934.64 | 212.79 | 207.25 | 16.22 | 5.43 | 4.32 | 4.98 | 5.40 | 5.22 | 5.42 | 4.94 | 4.84 | 3.97 |
| 0.33 | 1088.07 | 925.68 | 213.96 | 208.77 | 14.83 | 4.60 | 3.63 | 4.19 | 4.58 | 4.43 | 4.53 | 4.16 | 4.11 | 3.36 |
| ***Configuration 2*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.294 | 1106.55 | 905.52 | 183.00 | 167.95 | 21.10 | 8.48 | 6.81 | 8.10 | 8.36 | 8.50 | 8.65 | 7.90 | 7.41 | 6.41 |
| 0.33 | 1066.68 | 885.22 | 198.64 | 182.89 | 18.05 | 6.24 | 4.97 | 5.90 | 6.08 | 6.20 | 6.22 | 5.73 | 5.41 | 4.73 |
| 0.35 | 1037.80 | 874.40 | 203.46 | 189.00 | 16.00 | 4.94 | 3.93 | 4.64 | 4.77 | 4.88 | 4.80 | 4.47 | 4.26 | 3.75 |
| 0.35 | 1045.30 | 879.00 | 177.30 | 174.40 | 16.19 | 4.94 | 3.98 | 4.72 | 4.78 | 4.90 | 4.77 | 4.47 | 4.28 | 3.77 |
| 0.40 | 1058.47 | 887.60 | 194.84 | 195.48 | 16.66 | 5.28 | 4.18 | 5.03 | 5.09 | 5.21 | 5.13 | 4.75 | 4.55 | 4.00 |
| 0.45 | 1049.38 | 884.29 | 202.47 | 205.04 | 15.89 | 4.83 | 3.82 | 4.59 | 4.64 | 4.75 | 4.65 | 4.34 | 4.17 | 3.67 |
| 0.50 | 1044.04 | 883.40 | 211.51 | 216.03 | 15.11 | 4.41 | 3.52 | 4.19 | 4.24 | 4.35 | 4.23 | 3.97 | 3.83 | 3.38 |
| 0.55 | 1038.22 | 882.34 | 218.77 | 222.50 | 14.62 | 4.20 | 3.34 | 3.98 | 4.05 | 4.14 | 4.01 | 3.77 | 3.65 | 3.22 |
| 0.60 | 1033.82 | 881.53 | 221.23 | 224.33 | 14.29 | 4.03 | 3.21 | 3.82 | 3.89 | 3.98 | 3.85 | 3.62 | 3.51 | 3.09 |
| **105°F** | | | | | | | | | | | | | | |
| 0.307 | 1112.03 | 919.77 | 176.74 | 178.73 | 19.71 | 7.66 | 6.11 | 7.44 | 7.49 | 7.52 | 7.67 | 7.05 | 6.68 | 5.78 |
| 0.33 | 1079.59 | 904.50 | 189.95 | 193.29 | 17.14 | 5.80 | 4.62 | 5.58 | 5.64 | 5.66 | 5.67 | 5.30 | 5.07 | 4.40 |
| 0.40 | 1069.37 | 903.29 | 206.28 | 205.86 | 16.10 | 5.16 | 4.10 | 4.93 | 4.98 | 5.02 | 5.00 | 4.69 | 4.51 | 3.92 |
| 0.45 | 1059.60 | 899.68 | 212.21 | 215.80 | 15.20 | 4.70 | 3.72 | 4.46 | 4.52 | 4.57 | 4.51 | 4.25 | 4.11 | 3.57 |
| 0.50 | 1056.65 | 899.74 | 216.89 | 222.60 | 14.72 | 4.42 | 3.50 | 4.20 | 4.27 | 4.28 | 4.24 | 4.00 | 3.89 | 3.37 |
| 0.55 | 1051.45 | 898.55 | 222.55 | 228.78 | 14.26 | 4.21 | 3.32 | 3.99 | 4.06 | 4.05 | 4.02 | 3.80 | 3.70 | 3.21 |
| 0.60 | 1045.90 | 897.22 | 224.52 | 233.46 | 13.91 | 4.05 | 3.19 | 3.82 | 3.90 | 3.88 | 3.85 | 3.63 | 3.56 | 3.08 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 1126.64 | 933.73 | 182.51 | 179.69 | 19.69 | 7.68 | 6.08 | 7.48 | 7.48 | 7.59 | 7.63 | 7.02 | 6.73 | 5.76 |
| 0.32 | 1105.36 | 924.19 | 195.65 | 193.82 | 17.62 | 6.21 | 4.89 | 6.00 | 6.00 | 6.07 | 6.07 | 5.66 | 5.45 | 4.67 |
| 0.33 | 1089.42 | 919.23 | 200.98 | 200.83 | 16.41 | 5.39 | 4.25 | 5.17 | 5.19 | 5.24 | 5.20 | 4.89 | 4.75 | 4.06 |
| 0.34 | 1079.80 | 917.78 | 203.70 | 205.86 | 15.34 | 4.75 | 3.75 | 4.54 | 4.57 | 4.60 | 4.55 | 4.30 | 4.20 | 3.59 |
| ***Configuration 3*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.30 | 1180.94 | 977.70 | 169.15 | 168.00 | 20.48 | 8.78 | 7.12 | 8.36 | 8.36 | 8.89 | 8.58 | 8.34 | 7.85 | 6.77 |
| 0.33 | 1171.05 | 972.40 | 181.02 | 179.09 | 19.75 | 7.67 | 6.24 | 7.32 | 7.29 | 7.75 | 7.46 | 7.26 | 6.86 | 5.94 |
| 0.35 | 1143.13 | 954.30 | 191.06 | 189.06 | 18.23 | 6.50 | 5.29 | 6.22 | 6.15 | 6.58 | 6.31 | 6.15 | 5.81 | 5.06 |
| 0.35 | 1149.68 | 957.78 | 174.21 | 179.43 | 18.47 | 6.54 | 5.34 | 6.27 | 6.19 | 6.66 | 6.37 | 6.23 | 5.86 | 5.11 |
| 0.37 | 1103.20 | 931.16 | 190.64 | 196.65 | 15.65 | 4.65 | 3.81 | 4.44 | 4.38 | 4.70 | 4.46 | 4.38 | 4.18 | 3.66 |
| 0.45 | 1120.48 | 941.47 | 205.70 | 213.11 | 16.46 | 5.12 | 4.19 | 4.88 | 4.82 | 5.18 | 4.94 | 4.84 | 4.59 | 4.02 |
| 0.50 | 1110.87 | 938.00 | 211.53 | 223.47 | 15.73 | 4.67 | 3.82 | 4.45 | 4.39 | 4.72 | 4.49 | 4.41 | 4.20 | 3.68 |
| 0.55 | 1106.85 | 937.68 | 216.36 | 231.40 | 15.21 | 4.39 | 3.59 | 4.18 | 4.13 | 4.42 | 4.21 | 4.14 | 3.96 | 3.48 |
| 0.60 | 1101.20 | 936.82 | 223.19 | 237.62 | 14.84 | 4.17 | 3.41 | 3.97 | 3.91 | 4.21 | 3.99 | 3.92 | 3.76 | 3.30 |
| **105°F** | | | | | | | | | | | | | | |
| 0.30 | 1189.27 | 987.20 | 188.08 | 176.28 | 20.26 | 8.93 | 7.19 | 8.39 | 8.46 | 8.98 | 8.74 | 8.44 | 7.95 | 6.81 |
| 0.33 | 1176.81 | 980.53 | 203.31 | 190.08 | 19.39 | 7.47 | 6.01 | 7.03 | 7.06 | 7.52 | 7.28 | 7.03 | 6.65 | 5.73 |
| 0.35 | 1155.24 | 967.20 | 211.38 | 199.76 | 17.91 | 6.47 | 5.20 | 6.09 | 6.09 | 6.51 | 6.25 | 6.06 | 5.76 | 4.97 |
| 0.37 | 1113.43 | 944.06 | 214.19 | 204.05 | 15.28 | 4.64 | 3.72 | 4.34 | 4.34 | 4.66 | 4.37 | 4.29 | 4.15 | 3.58 |
| 0.45 | 1128.44 | 952.29 | 222.68 | 212.24 | 16.05 | 5.08 | 4.09 | 4.77 | 4.78 | 5.12 | 4.85 | 4.71 | 4.55 | 3.93 |
| 0.50 | 1122.31 | 950.97 | 228.12 | 218.71 | 15.43 | 4.68 | 3.77 | 4.39 | 4.40 | 4.71 | 4.44 | 4.34 | 4.21 | 3.63 |
| **115°F** | | | | | | | | | | | | | | |
| 0.35 | 1170.89 | 982.30 | 208.80 | 210.81 | 17.57 | 5.95 | 4.86 | 5.77 | 5.75 | 6.07 | 5.81 | 5.79 | 5.50 | 4.71 |
| 0.37 | 1121.10 | 951.97 | 192.44 | 189.78 | 15.19 | 4.37 | 3.55 | 4.21 | 4.22 | 4.45 | 4.21 | 4.19 | 4.07 | 3.47 |
| 0.37 | 1127.49 | 960.78 | 213.98 | 219.42 | 14.88 | 4.25 | 3.46 | 4.08 | 4.09 | 4.31 | 4.08 | 4.09 | 3.96 | 3.38 |

| TE/WT at Temp | Air>Rad 10 H2O | AirRad> 1 H2O | AirRad> 2 H2O | AirRad> 3 H2O | AirRad> 4 H2O | AirRad> 5 H2O | AirRad> 6 H2O | AirRad> 7 H2O | AirRad> 8 H2O | AirRad> 9 H2O | AirRad> 10 H2O | AirRad> TP1 H2O | AirRad> TP2 H2O | AirRad> TP3 H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.35 | 4.00 | 0.10 | 0.95 | 0.36 | 0.66 | 0.41 | 0.97 | 0.42 | 0.85 | 0.50 | 1 15 | 1.63 | 1.37 | 1.95 |
| 0.45 | 4.33 | 0.12 | 1.05 | 0.41 | 0.75 | 0.50 | 1.07 | 0.48 | 0.94 | 0.57 | 1.29 | 1.79 | 1.53 | 1.85 |
| 0.50 | 4.08 | 0.11 | 0.98 | 0.38 | 0.68 | 0.44 | 1.00 | 0.44 | 0.87 | 0.52 | 1.16 | 1.65 | 1.43 | 1.71 |
| 0.55 | 3.94 | 0.10 | 0.93 | 0.36 | 0.65 | 0.40 | 0.96 | 0.42 | 0.83 | 0.48 | 1.12 | 1.56 | 1.36 | 1.59 |
| 0.60 | 3.86 | 0.09 | 0.90 | 0.34 | 0.63 | 0.39 | 0.94 | 0 41 | 0.81 | 0.46 | 1.08 | 1.51 | 1.34 | 1 54 |
| **105°F** | | | | | | | | | | | | | | |
| 0.26 | 7.51 | 0.27 | 2.01 | 0.93 | 1.48 | 1.14 | 2.11 | 0.96 | 1.89 | 1.21 | 2.64 | 3.72 | 2.99 | 4.99 |
| 0.31 | 5.48 | 0.14 | 1.37 | 0.56 | 0.96 | 0.70 | 1 43 | 0.58 | 1.30 | 0.74 | 1.72 | 2.44 | 2.03 | 3.33 |
| 0.32 | 4.58 | 0.08 | 1.08 | 0.42 | 0.75 | 0.52 | 1.15 | 0.44 | 1.05 | 0.55 | 1.32 | 1.90 | 1.62 | 2.73 |
| 0.33 | 4.11 | 0.07 | 0.94 | 0.36 | 0.64 | 0.40 | 1.00 | 0.37 | 0.92 | 0.45 | 1.12 | 1.62 | 1.43 | 2.41 |
| 0.35 | 4.80 | 0 10 | 1 14 | 0.46 | 0.80 | 0.55 | 1.21 | 0 48 | 1.11 | 0.58 | 1.39 | 2.03 | 1.72 | 2 45 |
| 0.40 | 4.48 | 0.08 | 1.03 | 0.41 | 0 73 | 0.45 | 1 12 | 0.42 | 1.01 | 0.52 | 1.25 | 1.84 | 1.57 | 3.40 |
| 0.45 | 4.18 | 0.06 | 0.93 | 0.36 | 0.65 | 0.38 | 1.02 | 0.37 | 0.93 | 0.46 | 1 12 | 1 65 | 1 47 | 3.20 |
| 0.50 | 3.99 | 0.04 | 0.86 | 0.33 | 0.61 | 0.34 | 0.96 | 0.34 | 0.87 | 0.42 | 1.04 | 1.53 | 1.34 | 3.05 |
| 0.55 | 3.86 | 0.04 | 0.83 | 0.31 | 0.58 | 0.31 | 0.93 | 0.32 | 0.84 | 0.38 | 0.98 | 1.44 | 1.29 | 2.87 |
| 0.60 | 3.78 | 0.04 | 0.81 | 0.31 | 0.56 | 0.29 | 0.90 | 0.31 | 0.81 | 0.36 | 0.94 | 1.40 | 1.27 | 2.74 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 5.26 | 0.12 | 1.24 | 0.54 | 0.88 | 0.60 | 1.34 | 0.53 | 1.27 | 0.64 | 1.55 | 2.27 | 1.93 | 2.85 |
| 0.32 | 4.39 | 0.06 | 0.96 | 0 41 | 0.66 | 0.41 | 1.07 | 0.39 | 1.03 | 0.44 | 1.17 | 1 73 | 1 52 | 2.31 |
| 0.33 | 3.72 | 0.03 | 0.75 | 0.31 | 0.50 | 0 28 | 0.86 | 0.28 | 0.84 | 0.30 | 0.87 | 1.34 | 1.23 | 1.90 |
| ***Configuration 2*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.294 | 6.94 | 0.47 | 1.81 | 1.15 | 1.57 | 0.84 | 1 90 | 0.84 | 1.66 | 1.02 | 2.24 | 2.04 | 2.79 | 6.49 |
| 0.33 | 5.06 | 0.30 | 1.21 | 0.70 | 1.06 | 0.49 | 1.29 | 0.58 | 1.11 | 0.63 | 1.42 | 1.27 | 1.92 | 4.58 |
| 0.35 | 3.97 | 0.20 | 0.87 | 0.46 | 0.77 | 0.27 | 0.95 | 0.43 | 0.80 | 0.42 | 0.96 | 0.83 | 1.37 | 3.48 |
| 0.35 | 4.00 | 0.21 | 0.88 | 0.46 | 0.76 | 0.28 | 0.97 | 0.43 | 0.82 | 0.41 | 0.97 | 0.86 | 1.41 | 3.51 |
| 0.40 | 4.25 | 0.23 | 0.97 | 0.51 | 0.83 | 0.32 | 1 05 | 0 47 | 0.88 | 0.46 | 1.07 | 0.95 | 1.55 | 3.71 |
| 0.45 | 3.88 | 0.19 | 0.86 | 0.43 | 0.73 | 0.25 | 0.93 | 0 41 | 0.78 | 0.38 | 0.92 | 0.80 | 1.36 | 3.34 |
| 0.50 | 3.56 | 0.16 | 0.76 | 0.37 | 0.65 | 0.19 | 0.82 | 0.36 | 0.69 | 0.31 | 0.78 | 0.66 | 1.21 | 3.02 |
| 0.55 | 3.38 | 0.15 | 0.70 | 0.34 | 0.60 | 0.15 | 0.77 | 0.33 | 0.64 | 0.28 | 0.70 | 0.58 | 1.13 | 2.82 |
| 0 60 | 3.25 | 0.14 | 0.65 | 0.31 | 0.57 | 0.13 | 0.73 | 0.31 | 0.60 | 0.25 | 0.64 | 0.53 | 1.05 | 2 69 |
| **105°F** | | | | | | | | | | | | | | |
| 0 307 | 6.27 | 0.36 | 1.55 | 0.87 | 1.34 | 0.68 | 1 66 | 0.66 | 1.49 | 0.82 | 1.88 | 1.78 | 2.45 | 5.72 |
| 0.33 | 4.74 | 0.23 | 1.07 | 0.57 | 0.92 | 0.38 | 1 17 | 0.49 | 1.05 | 0.51 | 1 24 | 1.14 | 1.74 | 4.18 |
| 0.40 | 4.21 | 0.19 | 0.91 | 0.48 | 0.77 | 0.29 | 1.01 | 0 44 | 0.90 | 0.39 | 1.01 | 0.92 | 1.45 | 3 60 |
| 0.45 | 3.83 | 0.15 | 0.79 | 0.41 | 0 68 | 0.22 | 0.89 | 0.39 | 0.80 | 0.31 | 0.84 | 0.76 | 1.32 | 3.20 |
| 0.50 | 3.61 | 0.14 | 0.73 | 0.38 | 0.62 | 0.18 | 0.82 | 0.36 | 0.75 | 0.26 | 0.75 | 0.68 | 1.20 | 2.98 |
| 0 55 | 3.43 | 0.12 | 0.67 | 0.34 | 0.57 | 0.13 | 0.77 | 0.32 | 0.69 | 0.23 | 0.68 | 0.61 | 1.11 | 2 79 |
| 0 60 | 3.30 | 0.11 | 0.63 | 0.32 | 0.54 | 0.11 | 0.73 | 0.31 | 0.65 | 0.20 | 0.62 | 0.55 | 1.05 | 2.65 |
| **115°F** | | | | | | | | | | | | | | |
| 0.307 | 6.33 | 0.34 | 1.51 | 0.88 | 1 31 | 0.64 | 1.67 | 0.62 | 1.51 | 0.76 | 1 84 | 1.77 | 2.43 | 5.67 |
| 0.32 | 5.11 | 0.27 | 1 14 | 0.65 | 0.98 | 0.40 | 1 27 | 0.50 | 1.16 | 0.51 | 1 32 | 1.28 | 1.86 | 4.45 |
| 0.33 | 4.44 | 0.21 | 0.94 | 0.52 | 0.80 | 0.27 | 1.05 | 0 42 | 0.97 | 0.37 | 1.03 | 1.01 | 1.57 | 3.77 |
| 0.34 | 3.91 | 0.14 | 0.77 | 0 44 | 0.66 | 0.18 | 0.89 | 0.36 | 0.83 | 0.26 | 0.82 | 0.81 | 1.33 | 3.26 |
| ***Configuration 3*** | | | | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | | | | |
| 0.30 | 7 37 | 0.87 | 1.99 | 1.47 | 1.39 | 0.97 | 2.03 | 1.06 | 1.74 | 1 27 | 2.56 | 2.49 | 2.95 | 5.81 |
| 0.33 | 6.44 | 0.71 | 1.68 | 1.24 | 1.18 | 0.78 | 1.72 | 0.91 | 1.49 | 1.05 | 2.14 | 2.05 | 2.48 | 4.99 |
| 0.35 | 5.46 | 0.58 | 1.37 | 1.00 | 0.95 | 0.59 | 1.41 | 0.73 | 1 21 | 0.82 | 1.69 | 1.61 | 2.00 | 4.15 |
| 0.35 | 5.51 | 0.59 | 1.38 | 1.01 | 0.94 | 0.59 | 1 43 | 0.75 | 1.23 | 0.83 | 1.71 | 1.63 | 1.99 | 3.98 |
| 0.37 | 3.91 | 0.34 | 0.88 | 0.64 | 0.58 | 0.29 | 0.93 | 0.48 | 0.79 | 0.47 | 1.01 | 0.93 | 1.31 | 2.64 |
| 0.45 | 4.30 | 0.39 | 0.98 | 0.72 | 0.67 | 0.35 | 1.04 | 0.55 | 0.90 | 0.55 | 1.18 | 1.09 | 1 49 | 2.95 |
| 0.50 | 3.93 | 0.34 | 0.88 | 0.63 | 0.59 | 0.29 | 0.93 | 0 48 | 0.80 | 0.47 | 1.02 | 0.93 | 1.32 | 2.64 |
| 0.55 | 3.69 | 0.30 | 0.82 | 0.59 | 0.54 | 0.24 | 0.86 | 0 44 | 0.73 | 0.42 | 0.91 | 0.82 | 1.21 | 2.44 |
| 0.60 | 3.49 | 0.28 | 0.75 | 0.54 | 0.49 | 0.20 | 0.81 | 0.42 | 0.68 | 0.37 | 0.84 | 0.74 | 1.13 | 2.27 |
| **105°F** | | | | | | | | | | | | | | |
| 0.30 | 7.47 | 0.89 | 2.01 | 1.54 | 1.41 | 1.02 | 2.08 | 1 11 | 1.81 | 1.27 | 2.58 | 2.49 | 2.98 | 5.82 |
| 0.33 | 6.26 | 0.71 | 1.61 | 1.23 | 1.12 | 0.76 | 1.69 | 0.88 | 1.48 | 0.97 | 2.02 | 1.93 | 2.41 | 4.77 |
| 0.35 | 5.41 | 0.57 | 1.33 | 1.02 | 0.92 | 0.58 | 1.41 | 0.71 | 1.24 | 0.78 | 1 64 | 1.54 | 1.98 | 4.04 |
| 0.37 | 3.88 | 0.32 | 0.83 | 0.65 | 0.57 | 0.27 | 0.93 | 0.47 | 0.83 | 0.42 | 0.96 | 0.89 | 1 27 | 2.71 |
| 0 45 | 4 26 | 0.38 | 0.94 | 0.73 | 0.65 | 0.34 | 1.05 | 0.53 | 0.94 | 0.50 | 1.13 | 1.04 | 1.47 | 3.02 |
| 0.50 | 3.93 | 0.31 | 0.84 | 0.65 | 0.58 | 0.27 | 0.95 | 0.47 | 0.84 | 0.42 | 0.98 | 0.90 | 1.30 | 2.73 |
| **115°F** | | | | | | | | | | | | | | |
| 0.35 | 5.16 | 0 49 | 1.20 | 0.89 | 0.81 | 0.42 | 1.31 | 0.62 | 1.17 | 0.64 | 1.45 | 1.36 | 1.87 | 3.66 |
| 0.37 | 3 79 | 0.24 | 0.77 | 0.60 | 0.49 | 0 17 | 0.88 | 0.40 | 0.80 | 0.35 | 0.86 | 0.79 | 1.26 | 2.52 |
| 0.37 | 3.69 | 0.23 | 0.74 | 0.57 | 0.48 | 0.14 | 0.84 | 0.36 | 0 77 | 0.31 | 0.81 | 0.74 | 1.21 | 2.43 |

| TE/WT at Temp | AirRad> TP4 H2O | AirRad> TP5 H2O | AirRad> TP6 H2O | AirRad> TP7 H2O | AirRad> TP8 H2O | AirRad> TP9 H2O | AirRad> TP10 H2O | Air>Exh Grl 1 | Air>Exh Grl 2 | Air>Exh Grl 3 | Air>Exh Grl 4 | Air>Exh Grl 5 | Air>Exh Grl 6 | Air>Exh Grl TP1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | | | |
| 95°F | | | | | | | | | | | | | | |
| 0.35 | 1.65 | 1.35 | 1.83 | 3.28 | 1.24 | 0.91 | 2.09 | -0.09 | 0.59 | 0.37 | 0.54 | 0.26 | 0.40 | 1.20 |
| 0.45 | 1.83 | 1.51 | 2.00 | 3.58 | 1.38 | 1.04 | 2.30 | -0.07 | 0.68 | 0.44 | 0.62 | 0.32 | 0.47 | 1.32 |
| 0.50 | 1.68 | 1.41 | 1.86 | 3.33 | 1.27 | 0.95 | 2.14 | -0.08 | 0.61 | 0.38 | 0.55 | 0.27 | 0.41 | 1.20 |
| 0.55 | 1.60 | 1.37 | 1.77 | 3.18 | 1.22 | 0.90 | 2.06 | -0.09 | 0.58 | 0.36 | 0.51 | 0.24 | 0.38 | 1.16 |
| 0.60 | 1.56 | 1.31 | 1.72 | 3.10 | 1.18 | 0.87 | 1.99 | -0.10 | 0.55 | 0.33 | 0.49 | 0.22 | 0.35 | 1.13 |
| 105°F | | | | | | | | | | | | | | |
| 0.26 | 3.72 | 3.06 | 3.99 | 6.75 | 2.79 | 2.17 | 4.45 | 0.17 | 1.51 | 1.08 | 1.49 | 0.84 | 1.25 | 2.47 |
| 0.31 | 2.50 | 2.11 | 2.68 | 4.68 | 1.86 | 1.42 | 3.06 | -0.02 | 0.95 | 0.66 | 0.92 | 0.49 | 0.75 | 1.70 |
| 0.32 | 1.96 | 1.68 | 2.12 | 3.78 | 1.46 | 1.10 | 2.48 | -0.08 | 0.71 | 0.47 | 0.67 | 0.33 | 0.52 | 1.34 |
| 0.33 | 1.70 | 1.48 | 1.83 | 3.30 | 1.26 | 0.92 | 2.17 | -0.13 | 0.58 | 0.37 | 0.55 | 0.24 | 0.40 | 1.16 |
| 0.35 | 2.09 | 1.79 | 2.23 | 3.97 | 1.55 | 1.17 | 2.61 | -0.07 | 0.76 | 0.51 | 0.73 | 0.36 | 0.57 | 1.42 |
| 0.40 | 1.90 | 1.63 | 2.08 | 3.66 | 1.43 | 1.03 | 2.40 | -0.11 | 0.65 | 0.43 | 0.64 | 0.31 | 0.48 | 1.32 |
| 0.45 | 1.72 | 1.54 | 1.90 | 3.36 | 1.30 | 0.92 | 2.22 | -0.13 | 0.57 | 0.37 | 0.56 | 0.26 | 0.40 | 1.19 |
| 0.50 | 1.60 | 1.42 | 1.78 | 3.17 | 1.21 | 0.86 | 2.09 | -0.14 | 0.53 | 0.33 | 0.51 | 0.22 | 0.35 | 1.12 |
| 0.55 | 1.53 | 1.38 | 1.71 | 3.04 | 1.15 | 0.82 | 2.00 | -0.15 | 0.48 | 0.30 | 0.48 | 0.21 | 0.32 | 1.07 |
| 0.60 | 1.48 | 1.32 | 1.64 | 2.95 | 1.11 | 0.79 | 1.95 | -0.16 | 0.47 | 0.28 | 0.45 | 0.19 | 0.30 | 1.04 |
| 115°F | | | | | | | | | | | | | | |
| 0.307 | 2.36 | 2.04 | 2.56 | 4.42 | 1.78 | 1.26 | 2.87 | -0.08 | 0.86 | 0.60 | 0.86 | 0.41 | 0.66 | 1.54 |
| 0.32 | 1.86 | 1.63 | 2.01 | 3.52 | 1.39 | 0.94 | 2.31 | -0.16 | 0.63 | 0.41 | 0.62 | 0.26 | 0.44 | 1.19 |
| 0.33 | 1.47 | 1.34 | 1.61 | 2.86 | 1.09 | 0.71 | 1.89 | -0.22 | 0.45 | 0.27 | 0.44 | 0.15 | 0.28 | 0.93 |
| ***Configuration 2*** | | | | | | | | | | | | | | |
| 95°F | | | | | | | | | | | | | | |
| 0.294 | 2.97 | 2.54 | 3.29 | 6.03 | 2.40 | 1.81 | 4.13 | 0.23 | 1.40 | 0.98 | 1.33 | 0.78 | 1.07 | 2.46 |
| 0.33 | 1.97 | 1.74 | 2.20 | 4.16 | 1.59 | 1.17 | 2.84 | 0.05 | 0.88 | 0.60 | 0.80 | 0.46 | 0.61 | 1.69 |
| 0.35 | 1.39 | 1.23 | 1.58 | 3.08 | 1.14 | 0.79 | 2.12 | -0.05 | 0.59 | 0.37 | 0.50 | 0.27 | 0.36 | 1.22 |
| 0.35 | 1.45 | 1.27 | 1.60 | 3.11 | 1.17 | 0.79 | 2.13 | -0.06 | 0.61 | 0.40 | 0.54 | 0.27 | 0.37 | 1.22 |
| 0.40 | 1.56 | 1.40 | 1.71 | 3.33 | 1.27 | 0.89 | 2.28 | -0.02 | 0.68 | 0.45 | 0.59 | 0.31 | 0.43 | 1.33 |
| 0.45 | 1.37 | 1.23 | 1.51 | 2.98 | 1.12 | 0.78 | 2.04 | -0.06 | 0.59 | 0.37 | 0.49 | 0.25 | 0.34 | 1.17 |
| 0.50 | 1.20 | 1.08 | 1.33 | 2.67 | 0.97 | 0.66 | 1.84 | -0.08 | 0.50 | 0.30 | 0.41 | 0.18 | 0.27 | 1.03 |
| 0.55 | 1.11 | 1.01 | 1.23 | 2.48 | 0.90 | 0.59 | 1.74 | -0.11 | 0.45 | 0.25 | 0.36 | 0.15 | 0.21 | 0.94 |
| 0.60 | 1.05 | 0.95 | 1.15 | 2.36 | 0.85 | 0.54 | 1.64 | -0.12 | 0.41 | 0.22 | 0.33 | 0.12 | 0.18 | 0.89 |
| 105°F | | | | | | | | | | | | | | |
| 0.307 | 2.68 | 2.23 | 2.83 | 5.33 | 2.08 | 1.53 | 3.60 | 0.12 | 1.16 | 0.81 | 1.11 | 0.63 | 0.88 | 2.06 |
| 0.33 | 1.85 | 1.58 | 1.96 | 3.81 | 1.43 | 1.00 | 2.60 | -0.03 | 0.75 | 0.48 | 0.68 | 0.37 | 0.51 | 1.44 |
| 0.40 | 1.56 | 1.34 | 1.65 | 3.27 | 1.22 | 0.83 | 2.25 | -0.07 | 0.60 | 0.38 | 0.54 | 0.28 | 0.38 | 1.22 |
| 0.45 | 1.36 | 1.20 | 1.44 | 2.89 | 1.06 | 0.70 | 2.00 | -0.11 | 0.50 | 0.30 | 0.43 | 0.22 | 0.30 | 1.07 |
| 0.50 | 1.25 | 1.11 | 1.33 | 2.69 | 0.97 | 0.63 | 1.86 | -0.12 | 0.44 | 0.26 | 0.38 | 0.18 | 0.25 | 0.97 |
| 0.55 | 1.16 | 1.04 | 1.23 | 2.52 | 0.89 | 0.56 | 1.75 | -0.15 | 0.39 | 0.21 | 0.34 | 0.15 | 0.21 | 0.90 |
| 0.60 | 1.07 | 0.99 | 1.16 | 2.38 | 0.84 | 0.52 | 1.67 | -0.17 | 0.36 | 0.19 | 0.30 | 0.13 | 0.17 | 0.85 |
| 115°F | | | | | | | | | | | | | | |
| 0.307 | 2.70 | 2.20 | 2.83 | 5.34 | 2.09 | 1.48 | 3.64 | 0.08 | 1.14 | 0.80 | 1.13 | 0.62 | 0.87 | 2.03 |
| 0.32 | 2.04 | 1.76 | 2.15 | 4.13 | 1.58 | 1.07 | 2.83 | -0.04 | 0.81 | 0.55 | 0.78 | 0.41 | 0.58 | 1.54 |
| 0.33 | 1.69 | 1.50 | 1.79 | 3.47 | 1.30 | 0.84 | 2.41 | -0.10 | 0.62 | 0.41 | 0.59 | 0.30 | 0.42 | 1.26 |
| 0.34 | 1.41 | 1.27 | 1.51 | 2.96 | 1.09 | 0.67 | 2.07 | -0.14 | 0.48 | 0.30 | 0.46 | 0.21 | 0.30 | 1.04 |
| ***Configuration 3*** | | | | | | | | | | | | | | |
| 95°F | | | | | | | | | | | | | | |
| 0.30 | 3.17 | 3.39 | 3.37 | 4.53 | 2.71 | 1.77 | 4.12 | 0.05 | 1.50 | 1.02 | 1.56 | 0.84 | 1.17 | 2.48 |
| 0.33 | 2.66 | 2.88 | 2.85 | 3.84 | 2.28 | 1.46 | 3.53 | -0.02 | 1.24 | 0.83 | 1.28 | 0.65 | 0.93 | 2.07 |
| 0.35 | 2.16 | 2.36 | 2.31 | 3.14 | 1.85 | 1.14 | 2.91 | -0.09 | 0.98 | 0.63 | 0.99 | 0.47 | 0.70 | 1.63 |
| 0.35 | 2.19 | 2.38 | 2.32 | 3.18 | 1.86 | 1.15 | 2.95 | -0.10 | 0.99 | 0.65 | 1.01 | 0.48 | 0.72 | 1.65 |
| 0.37 | 1.38 | 1.54 | 1.47 | 2.07 | 1.16 | 0.63 | 1.94 | -0.22 | 0.56 | 0.33 | 0.54 | 0.20 | 0.34 | 1.00 |
| 0.45 | 1.57 | 1.75 | 1.66 | 2.31 | 1.32 | 0.76 | 2.16 | -0.19 | 0.67 | 0.41 | 0.64 | 0.27 | 0.43 | 1.12 |
| 0.50 | 1.38 | 1.54 | 1.47 | 2.05 | 1.16 | 0.64 | 1.95 | -0.22 | 0.57 | 0.34 | 0.54 | 0.21 | 0.34 | 0.98 |
| 0.55 | 1.27 | 1.40 | 1.34 | 1.89 | 1.06 | 0.57 | 1.85 | -0.22 | 0.51 | 0.31 | 0.49 | 0.18 | 0.30 | 0.92 |
| 0.60 | 1.18 | 1.32 | 1.24 | 1.77 | 0.98 | 0.51 | 1.75 | -0.24 | 0.46 | 0.27 | 0.44 | 0.16 | 0.26 | 0.85 |
| 105°F | | | | | | | | | | | | | | |
| 0.30 | 3.22 | 3.47 | 3.46 | 4.45 | 2.77 | 1.77 | 4.19 | 0.02 | 1.50 | 1.02 | 1.57 | 0.90 | 1.23 | 2.49 |
| 0.33 | 2.57 | 2.83 | 2.78 | 3.59 | 2.22 | 1.36 | 3.43 | -0.07 | 1.15 | 0.77 | 1.21 | 0.67 | 0.92 | 1.99 |
| 0.35 | 2.13 | 2.34 | 2.31 | 3.01 | 1.83 | 1.07 | 2.90 | -0.13 | 0.93 | 0.61 | 0.97 | 0.50 | 0.71 | 1.66 |
| 0.37 | 1.37 | 1.52 | 1.47 | 1.99 | 1.16 | 0.57 | 1.94 | -0.25 | 0.51 | 0.30 | 0.53 | 0.22 | 0.34 | 0.98 |
| 0.45 | 1.55 | 1.76 | 1.66 | 2.23 | 1.33 | 0.69 | 2.17 | -0.23 | 0.61 | 0.38 | 0.64 | 0.29 | 0.43 | 1.15 |
| 0.50 | 1.38 | 1.57 | 1.50 | 2.00 | 1.17 | 0.59 | 1.96 | -0.25 | 0.52 | 0.32 | 0.54 | 0.23 | 0.34 | 0.99 |
| 115°F | | | | | | | | | | | | | | |
| 0.35 | 2.04 | 2.22 | 2.16 | 2.88 | 1.66 | 0.94 | 2.74 | -0.26 | 0.81 | 0.54 | 0.88 | 0.40 | 0.60 | 1.39 |
| 0.37 | 1.33 | 1.54 | 1.43 | 1.95 | 1.09 | 0.49 | 1.89 | -0.33 | 0.45 | 0.26 | 0.49 | 0.16 | 0.28 | 0.88 |
| 0.37 | 1.28 | 1.48 | 1.38 | 1.87 | 1.03 | 0.46 | 1.84 | -0.33 | 0.42 | 0.25 | 0.47 | 0.14 | 0.26 | 0.84 |

| TE/WT at Temp | Air>Exh Grl TP2 | Air>Exh Grl TP3 | Air>Exh Grl TP4 | Air>Exh Grl TP5 | Air>Exh Grl TP6 | AirExh GRL> 1 | AirExh GRL> 2 | AirExh GRL> 3 | AirExh GRL> 4 | AirExh GRL> 5 | AirExh GRL> 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | |
| 0.35 | 1.38 | 0.99 | 1.13 | 0.89 | 1.65 | -0.78 | -0.49 | -0.85 | -0.88 | -0.76 | -0.80 |
| 0.45 | 1.52 | 1.12 | 1.29 | 1.03 | 1.82 | -0.80 | -0.47 | -0.88 | -0.92 | -0.78 | -0.82 |
| 0.50 | 1.39 | 1.02 | 1.17 | 0.92 | 1.66 | -0.78 | -0.46 | -0.85 | -0.89 | -0.76 | -0.80 |
| 0.55 | 1.33 | 0.97 | 1.10 | 0.87 | 1.58 | -0.77 | -0.46 | -0.85 | -0.88 | -0.75 | -0.79 |
| 0.60 | 1.29 | 0.95 | 1.06 | 0.83 | 1.53 | -0.76 | -0.45 | -0.84 | -0.86 | -0.74 | -0.78 |
| **105°F** | | | | | | | | | | | |
| 0.26 | 2.98 | 2.35 | 2.87 | 2.41 | 3.69 | -1.02 | -0.54 | -1.17 | -1.25 | -1.02 | -1.05 |
| 0.31 | 2.02 | 1.54 | 1.83 | 1.54 | 2.46 | -0.89 | -0.50 | -1.00 | -1.04 | -0.85 | -0.90 |
| 0.32 | 1.59 | 1.18 | 1.37 | 1.16 | 1.94 | -0.83 | -0.49 | -0.92 | -0.94 | -0.78 | -0.84 |
| 0.33 | 1.40 | 1.00 | 1.14 | 0.96 | 1.64 | -0.80 | -0.48 | -0.88 | -0.89 | -0.74 | -0.81 |
| 0.35 | 1.72 | 1.26 | 1.47 | 1.25 | 2.04 | -0.85 | -0.48 | -0.94 | -0.97 | -0.79 | -0.85 |
| 0.40 | 1.55 | 1.13 | 1.29 | 1.04 | 1.86 | -0.83 | -0.37 | -0.90 | -0.93 | -0.76 | -0.83 |
| 0.45 | 1.41 | 1.02 | 1.14 | 0.90 | 1.67 | -0.81 | -0.37 | -0.88 | -0.90 | -0.73 | -0.81 |
| 0.50 | 1.33 | 0.94 | 1.05 | 0.83 | 1.56 | -0.80 | -0.36 | -0.87 | -0.87 | -0.72 | -0.80 |
| 0.55 | 1.27 | 0.90 | 0.99 | 0.78 | 1.48 | -0.80 | -0.36 | -0.85 | -0.86 | -0.70 | -0.79 |
| 0.60 | 1.23 | 0.86 | 0.96 | 0.74 | 1.43 | -0.79 | -0.36 | -0.84 | -0.84 | -0.70 | -0.78 |
| **115°F** | | | | | | | | | | | |
| 0.307 | 1.88 | 1.40 | 1.66 | 1.40 | 2.24 | -0.90 | -0.39 | -1.01 | -1.03 | -0.80 | -0.90 |
| 0.32 | 1.48 | 1.06 | 1.22 | 1.03 | 1.75 | -0.86 | -0.38 | -0.94 | -0.94 | -0.73 | -0.84 |
| 0.33 | 1.17 | 0.80 | 0.89 | 0.75 | 1.32 | -0.81 | -0.38 | -0.89 | -0.87 | -0.67 | -0.80 |
| ***Configuration 2*** | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | |
| 0.294 | 2.80 | 2.15 | 2.43 | 2.05 | 3.26 | -1.02 | -0.59 | -1.01 | -1.13 | -0.97 | -1.04 |
| 0.33 | 1.91 | 1.42 | 1.49 | 1.28 | 2.14 | -0.88 | -0.55 | -0.86 | -0.95 | -0.82 | -0.89 |
| 0.35 | 1.40 | 1.00 | 0.96 | 0.81 | 1.49 | -0.80 | -0.53 | -0.78 | -0.84 | -0.74 | -0.82 |
| 0.35 | 1.42 | 0.98 | 0.95 | 0.83 | 1.51 | -0.80 | -0.45 | -0.78 | -0.85 | -0.74 | -0.82 |
| 0.40 | 1.54 | 1.09 | 1.10 | 0.95 | 1.62 | -0.81 | -0.45 | -0.78 | -0.88 | -0.75 | -0.83 |
| 0.45 | 1.37 | 0.95 | 0.93 | 0.80 | 1.42 | -0.79 | -0.44 | -0.77 | -0.84 | -0.72 | -0.81 |
| 0.50 | 1.22 | 0.84 | 0.78 | 0.66 | 1.23 | -0.76 | -0.43 | -0.74 | -0.81 | -0.70 | -0.78 |
| 0.55 | 1.12 | 0.77 | 0.68 | 0.58 | 1.12 | -0.75 | -0.42 | -0.73 | -0.80 | -0.68 | -0.77 |
| 0.60 | 1.05 | 0.72 | 0.64 | 0.53 | 1.03 | -0.74 | -0.38 | -0.73 | -0.78 | -0.67 | -0.76 |
| **105°F** | | | | | | | | | | | |
| 0.307 | 2.42 | 1.84 | 2.06 | 1.78 | 2.78 | -1.00 | -0.56 | -0.97 | -1.08 | -0.90 | -0.99 |
| 0.33 | 1.70 | 1.25 | 1.30 | 1.14 | 1.87 | -0.88 | -0.45 | -0.85 | -0.93 | -0.78 | -0.88 |
| 0.40 | 1.47 | 1.04 | 1.04 | 0.91 | 1.55 | -0.84 | -0.44 | -0.81 | -0.88 | -0.74 | -0.84 |
| 0.45 | 1.31 | 0.90 | 0.86 | 0.75 | 1.33 | -0.81 | -0.44 | -0.78 | -0.84 | -0.70 | -0.81 |
| 0.50 | 1.20 | 0.82 | 0.75 | 0.67 | 1.21 | -0.80 | -0.39 | -0.77 | -0.83 | -0.69 | -0.80 |
| 0.55 | 1.12 | 0.75 | 0.68 | 0.58 | 1.12 | -0.79 | -0.38 | -0.75 | -0.81 | -0.67 | -0.78 |
| 0.60 | 1.05 | 0.70 | 0.62 | 0.52 | 1.03 | -0.78 | -0.35 | -0.74 | -0.79 | -0.66 | -0.77 |
| **115°F** | | | | | | | | | | | |
| 0.307 | 2.42 | 1.81 | 2.03 | 1.71 | 2.75 | -1.03 | -0.51 | -0.99 | -1.09 | -0.88 | -1.00 |
| 0.32 | 1.85 | 1.35 | 1.43 | 1.21 | 2.03 | -0.94 | -0.49 | -0.90 | -0.97 | -0.78 | -0.92 |
| 0.33 | 1.53 | 1.09 | 1.10 | 0.93 | 1.65 | -0.89 | -0.42 | -0.85 | -0.91 | -0.73 | -0.88 |
| 0.34 | 1.30 | 0.89 | 0.86 | 0.71 | 1.36 | -0.85 | -0.39 | -0.81 | -0.86 | -0.69 | -0.83 |
| ***Configuration 3*** | | | | | | | | | | | |
| **95°F** | | | | | | | | | | | |
| 0.30 | 3.12 | 2.30 | 2.75 | 2.58 | 3.49 | -1.08 | -0.48 | -1.08 | -1.13 | -0.99 | -1.14 |
| 0.33 | 2.64 | 1.93 | 2.27 | 2.14 | 2.94 | -1.01 | -0.47 | -1.00 | -1.05 | -0.92 | -1.06 |
| 0.35 | 2.15 | 1.56 | 1.78 | 1.68 | 2.35 | -0.93 | -0.45 | -0.92 | -0.97 | -0.85 | -0.98 |
| 0.35 | 2.21 | 1.57 | 1.80 | 1.72 | 2.36 | -0.93 | -0.46 | -0.92 | -0.97 | -0.84 | -0.99 |
| 0.37 | 1.42 | 0.96 | 1.02 | 0.99 | 1.43 | -0.80 | -0.43 | -0.79 | -0.82 | -0.72 | -0.86 |
| 0.45 | 1.59 | 1.10 | 1.20 | 1.15 | 1.66 | -0.84 | -0.40 | -0.82 | -0.86 | -0.75 | -0.88 |
| 0.50 | 1.40 | 0.96 | 1.02 | 0.99 | 1.43 | -0.80 | -0.39 | -0.78 | -0.83 | -0.72 | -0.85 |
| 0.55 | 1.32 | 0.88 | 0.91 | 0.88 | 1.29 | -0.79 | -0.39 | -0.77 | -0.81 | -0.70 | -0.83 |
| 0.60 | 1.24 | 0.80 | 0.81 | 0.79 | 1.20 | -0.77 | -0.39 | -0.75 | -0.79 | -0.69 | -0.82 |
| **105°F** | | | | | | | | | | | |
| 0.30 | 3.16 | 2.32 | 2.79 | 2.62 | 3.54 | -1.12 | -0.48 | -1.10 | -1.14 | -0.99 | -1.13 |
| 0.33 | 2.56 | 1.84 | 2.17 | 2.03 | 2.80 | -1.03 | -0.47 | -1.00 | -1.04 | -0.89 | -1.05 |
| 0.35 | 2.15 | 1.52 | 1.73 | 1.63 | 2.30 | -0.97 | -0.39 | -0.92 | -0.90 | -0.82 | -0.97 |
| 0.37 | 1.40 | 0.92 | 0.97 | 0.93 | 1.39 | -0.84 | -0.38 | -0.80 | -0.83 | -0.70 | -0.86 |
| 0.45 | 1.57 | 1.06 | 1.15 | 1.10 | 1.60 | -0.86 | -0.36 | -0.83 | -0.87 | -0.73 | -0.88 |
| 0.50 | 1.42 | 0.94 | 0.99 | 0.95 | 1.41 | -0.84 | -0.35 | -0.80 | -0.83 | -0.70 | -0.86 |
| **115°F** | | | | | | | | | | | |
| 0.35 | 1.98 | 1.39 | 1.54 | 1.47 | 2.05 | -0.96 | -0.37 | -0.94 | -0.96 | -0.81 | -0.99 |
| 0.37 | 1.33 | 0.87 | 0.87 | 0.84 | 1.27 | -0.85 | -0.36 | -0.82 | -0.83 | -0.70 | -0.87 |
| 0.37 | 1.29 | 0.83 | 0.83 | 0.79 | 1.21 | -0.85 | -0.33 | -0.82 | -0.83 | -0.69 | -0.87 |

# APPENDIX B

*RAW REDUCED TEST DATA*

*For*

*Fuel, Max Speed and Mixer Tests*

**Max Speed Test (w/DF-2 Fuel)**

| | FUEL usage | ENGINE SPEED | NORTH TORQUE | SOUTH TORQUE | NORTH SPEED | SOUTH SPEED | AVERAGE SPEED | Translated Vehicle Speed | TOTAL SHP | pBARO HG | GEN OIL DCT-HZ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | |
| 12/30/2003 | 163.5 | 2287 | 123 | 121 | 627 | 663 | 645 | 37.6 | 299 | 29.29 | 488.69 |
| 12/30/2003 | 165.8 | 2303 | 122 | 121 | 637 | 667 | 652 | 38.1 | 302 | 29.30 | 488.48 |
| 12/30/2003 | 163.3 | 2280 | 121 | 122 | 634 | 660 | 647 | 37.8 | 299 | 29.30 | 487.65 |
| | | | | | | | | 37.8 | 300 | | |
| ***Configuration 3*** | | | | | | | | | | | |
| 4/26/2004 | 171.1 | 2361 | 117 | 132 | 668 | 684 | 676 | 39.5 | 320 | 29.17 | 497.17 |
| 4/26/2004 | 171.9 | 2337 | 119 | 127 | 661 | 677 | 669 | 39.1 | 312 | 29.16 | 490.50 |
| 4/26/2004 | 175.2 | 2327 | 107 | 136 | 659 | 674 | 667 | 38.9 | 309 | 29.14 | 498.95 |
| 4/26/2004 | 177.8 | 2353 | 115 | 134 | 669 | 682 | 676 | 39.4 | 321 | 29.13 | 499.68 |
| | | | | | | | | 39.2 | 315 | | |
| | | | | | | | | calc | calc | | |

**Fuel Consumption**

| | FUEL usage | ENGINE SPEED | NORTH TORQUE | SOUTH TORQUE | NORTH SPEED | SOUTH SPEED | TOTAL SHP | pBARO HG | GEN OIL DCT-HZ |
|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | |
| DF-2, 10/15/03 | 86.26 | 1483 | 106.8 | 110.8 | 428 | 430 | 177.91 | 29.08 | 1.00 |
| DF-2, 10/15/03 | 96.89 | 1486 | 114.7 | 114.1 | 429 | 431 | 187.35 | 29.10 | 1.00 |
| | ***91.57*** | | | | | | | | |
| JP-8, 10/09/03 | 90.22 | 1478 | 114.9 | 115.8 | 428 | 430 | 188.41 | 29.44 | 1.00 |
| JP-8, 10/09/03 | 91.39 | 1474 | 118.2 | 111.6 | 425 | 428 | 186.63 | 29.42 | 1.00 |
| | ***90.80*** | | | | | | | | |
| ***Configuration 3*** | | | | | | | | | |
| DF-2, 4/21/04 | 77.94 | 1480 | 119.3 | 116.0 | 428 | 430 | 192.11 | 28.89 | 409.22 |
| DF-2, 4/22/04 | 86.71 | 1480 | 118.0 | 112.3 | 427 | 429 | 187.72 | 29.41 | 416.26 |
| DF-2, 4/22/04 | 85.18 | 1474 | 115.0 | 109.2 | 427 | 429 | 182.62 | 29.40 | 414.76 |
| | ***83.27*** | | | | | | | | |
| JP-8, 4/27/04 | 86.74 | 1478 | 121.5 | 113.8 | 428 | 430 | 192.12 | 29.22 | 417.05 |
| JP-8, 4/28/04 | 86.54 | 1478 | 110.8 | 118.8 | 428 | 430 | 187.47 | 29.36 | 413.55 |
| JP-8, 4/28/04 | 86.74 | 1479 | 103.6 | 125.9 | 428 | 430 | 187.57 | 29.30 | 414.02 |
| | ***86.67*** | | | | | | | | |
| values in ***bold italics*** are averages | | | | | | | calc | | |

**Mixer Data, 4/16/2004**

| | FUEL usage | ENGINE SPEED | NORTH TORQUE | SOUTH TORQUE | NORTH SPEED | SOUTH SPEED | pBARO HG | GEN OIL DCT-HZ |
|---|---|---|---|---|---|---|---|---|
| ***Configuration 3*** | | | | | | | | |
| 0.33 | 167.24 | 2119.55 | 885.36 | 857.59 | 103.94 | 103.96 | 29.38 | 513.36 |
| 0.35 | 156.14 | 1944.00 | 926.86 | 898.48 | 95.70 | 95.70 | 29.36 | 498.71 |
| 0.37 | 136.14 | 1630.55 | 980.23 | 942.55 | 80.35 | 80.36 | 29.34 | 464.77 |

**Max Speed Test (w/DF-2 Fuel)**

| | FUEL usage | ENGINE SPEED | NORTH TORQUE | SOUTH TORQUE | NORTH SPEED | SOUTH SPEED | AVERAGE SPEED | Translated Vehicle Speed | TOTAL SHP | pBARO HG | GEN OIL DCT-HZ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | |
| 12/30/2003 | 163.5 | 2287 | 123 | 121 | 627 | 663 | 645 | 37.6 | 299 | 29.29 | 488.69 |
| 12/30/2003 | 165.8 | 2303 | 122 | 121 | 637 | 667 | 652 | 38.1 | 302 | 29.30 | 488.48 |
| 12/30/2003 | 163.3 | 2280 | 121 | 122 | 634 | 660 | 647 | 37.8 | 299 | 29.30 | 487.65 |
| | | | | | | | | 37.8 | 300 | | |
| ***Configuration 3*** | | | | | | | | | | | |
| 4/26/2004 | 171.1 | 2361 | 117 | 132 | 668 | 684 | 676 | 39.5 | 320 | 29.17 | 497.17 |
| 4/26/2004 | 171.9 | 2337 | 119 | 127 | 661 | 677 | 669 | 39.1 | 312 | 29.16 | 490.50 |
| 4/26/2004 | 175.2 | 2327 | 107 | 136 | 659 | 674 | 667 | 38.9 | 309 | 29.14 | 498.95 |
| 4/26/2004 | 177.8 | 2353 | 115 | 134 | 669 | 682 | 675 | 39.4 | 321 | 29.13 | 499.68 |
| | | | | | | | | 39.2 | 315 | | |
| | | | | | | | | calc | calc | | |

**Fuel Consumption**

| | FUEL usage | ENGINE SPEED | NORTH TORQUE | SOUTH TORQUE | NORTH SPEED | SOUTH SPEED | TOTAL SHP | pBARO HG | GEN OIL DCT-HZ |
|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | |
| DF-2, 10/15/03 | 86.26 | 1483 | 106.8 | 110.8 | 428 | 430 | 177.91 | 29.08 | 1.00 |
| DF-2, 10/15/03 | 96.89 | 1486 | 114.7 | 114.1 | 429 | 431 | 187.36 | 29.10 | 1.00 |
| | ***91.57*** | | | | | | | | |
| JP-8, 10/09/03 | 90.22 | 1478 | 114.9 | 115.8 | 428 | 430 | 188.41 | 29.44 | 1.00 |
| JP-8, 10/09/03 | 91.39 | 1474 | 118.2 | 111.6 | 425 | 428 | 186.63 | 29.42 | 1.00 |
| | ***90.80*** | | | | | | | | |
| ***Configuration 3*** | | | | | | | | | |
| DF-2, 4/21/04 | 77.94 | 1480 | 119.3 | 116.0 | 428 | 430 | 192.11 | 28.89 | 409.22 |
| DF-2, 4/22/04 | 86.71 | 1480 | 118.0 | 112.3 | 427 | 429 | 187.72 | 29.41 | 416.26 |
| DF-2, 4/22/04 | 85.18 | 1474 | 115.0 | 109.2 | 427 | 429 | 182.62 | 29.40 | 414.76 |
| | ***83.27*** | | | | | | | | |
| JP-8, 4/27/04 | 86.74 | 1478 | 121.5 | 113.8 | 428 | 430 | 192.12 | 29.22 | 417.05 |
| JP-8, 4/28/04 | 86.54 | 1478 | 110.8 | 118.8 | 428 | 430 | 187.47 | 29.36 | 413.55 |
| JP-8, 4/28/04 | 86.74 | 1479 | 103.6 | 125.9 | 428 | 430 | 187.57 | 29.30 | 414.02 |
| | ***86.67*** | | | | | | | | |
| values in ***bold italics*** are averages | | | | | | | calc | | |

**Mixer Data, 4/16/2004**

| | FUEL usage | ENGINE SPEED | NORTH TORQUE | SOUTH TORQUE | NORTH SPEED | SOUTH SPEED | pBARO HG | GEN OIL DCT-HZ |
|---|---|---|---|---|---|---|---|---|
| ***Configuration 3*** | | | | | | | | |
| 0.33 | 167.24 | 2119.55 | 885.36 | 857.69 | 103.94 | 103.96 | 29.38 | 513.36 |
| 0.35 | 156.14 | 1944.00 | 926.86 | 898.48 | 95.70 | 95.70 | 29.36 | 498.71 |
| 0.37 | 136.14 | 1630.55 | 980.23 | 942.55 | 80.35 | 80.36 | 29.34 | 464.77 |

**Max Speed Test (w/DF-2 Fuel)**

| | ENG OIL SUMP | OIL TEMP GALLERY | OIL PSI GALLERY | OIL B4 ENG CLR | TRANS OI SUMP | TRANS MAIN psi | OIL B4 TRAN CLR | OIL AFT TRAN CLR | FUEL SUP °F | FUEL RET °F | FUEL SUP psi | FUEL AFT PUMP psi |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| 12/30/2003 | 236.48 | 206.00 | 58.49 | 229.98 | 201.52 | 152.31 | 204.38 | 189.59 | 122.10 | 172.27 | 4.22 | 78.16 |
| 12/30/2003 | 232.35 | 202.96 | 60.60 | 225.45 | 202.69 | 152.31 | 205.80 | 188.76 | 120.04 | 168.17 | 4.23 | 78.46 |
| 12/30/2003 | 236.27 | 206.73 | 58.37 | 229.95 | 207.41 | 151.84 | 210.62 | 192.90 | 121.32 | 171.84 | 4.20 | 78.08 |
| ***Configuration 3*** | | | | | | | | | | | | |
| 4/26/2004 | 241.36 | 211.52 | 63.38 | 232.23 | 191.41 | 153.34 | 193.20 | 182.18 | 122.78 | 170.02 | 4.03 | 80.48 |
| 4/26/2004 | 237.16 | 208.13 | 63.86 | 228.11 | 196.32 | 153.04 | 198.26 | 182.73 | 120.54 | 165.13 | 4.09 | 80.38 |
| 4/26/2004 | 244.33 | 214.99 | 63.11 | 235.88 | 198.61 | 152.92 | 200.50 | 187.42 | 123.67 | 171.60 | 4.00 | 80.10 |
| 4/26/2004 | 244.75 | 216.33 | 63.12 | 236.13 | 204.45 | 152.85 | 206.27 | 192.16 | 118.41 | 169.19 | 4.01 | 80.41 |

**Fuel Consumption**

| | ENG OIL SUMP | OIL TEMP GALLERY | OIL PSI GALLERY | OIL B4 ENG CLR | TRANS OI SUMP | TRANS MAIN psi | OIL B4 TRAN CLR | OIL AFT TRAN CLR | FUEL SUP °F | FUEL RET °F | FUEL SUP psi | FUEL AFT PUMP psi |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| DF-2, 10/15/03 | 200.22 | 177.12 | 65.51 | 197.74 | 175.98 | 146.84 | 177.13 | 165.97 | 124.53 | 145.89 | 4.13 | 70.36 |
| DF-2, 10/15/03 | 206.55 | 182.08 | 62.45 | 204.33 | 181.19 | 146.53 | 182.37 | 170.65 | 125.41 | 148.54 | 4.07 | 70.40 |
| JP-8, 10/09/03 | 203.31 | 178.53 | 65.58 | 201.11 | 179.59 | 147.08 | 183.26 | 168.78 | 126.05 | 147.56 | 5.00 | 69.65 |
| JP-8, 10/09/03 | 202.83 | 177.80 | 64.07 | 200.72 | 177.33 | 147.05 | 180.85 | 167.24 | 124.75 | 146.40 | 5.12 | 69.55 |
| ***Configuration 3*** | | | | | | | | | | | | |
| DF-2, 4/21/04 | 203.74 | 181.79 | 53.55 | 199.38 | 172.71 | 146.90 | 174.03 | 161.21 | 120.39 | 139.77 | 3.81 | 71.15 |
| DF-2, 4/22/04 | 210.16 | 186.69 | 52.41 | 205.92 | 178.97 | 146.99 | 181.28 | 166.56 | 120.19 | 141.75 | 3.78 | 70.96 |
| DF-2, 4/22/04 | 210.05 | 186.84 | 51.73 | 205.92 | 179.33 | 146.88 | 181.49 | 166.83 | 121.73 | 142.56 | 3.74 | 70.90 |
| JP-8, 4/27/04 | 213.61 | 190.03 | 50.23 | 209.34 | 181.24 | 146.82 | 183.46 | 169.70 | 122.64 | 146.55 | -2.04 | 61.20 |
| JP-8, 4/28/04 | 209.94 | 187.79 | 50.39 | 206.00 | 178.70 | 146.57 | 180.08 | 167.06 | 122.38 | 144.41 | 3.89 | 69.53 |
| JP-8, 4/28/04 | 212.18 | 189.87 | 49.12 | 208.21 | 181.24 | 146.35 | 182.64 | 169.51 | 121.95 | 145.25 | 3.85 | 69.49 |

**Mixer Data, 4/16/2004**

| | ENG OIL SUMP | OIL TEMP GALLERY | OIL PSI GALLERY | OIL B4 ENG CLR | TRANS OI SUMP | TRANS MAIN psi | OIL B4 TRAN CLR | OIL AFT TRAN CLR | FUEL SUP °F | FUEL RET °F | FUEL SUP psi | FUEL AFT PUMP psi |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 3*** | | | | | | | | | | | | |
| 0.33 | 279.05 | 252.30 | 55.42 | 274.42 | 239.25 | 146.84 | 242.00 | 227.93 | 137.27 | 198.18 | 4.14 | 76.49 |
| 0.35 | 276.86 | 250.05 | 51.67 | 272.14 | 236.79 | 145.18 | 239.45 | 226.16 | 137.21 | 193.10 | 4.11 | 74.80 |
| 0.37 | 272.48 | 245.09 | 42.32 | 267.21 | 229.60 | 143.34 | 231.64 | 221.13 | 137.69 | 182.75 | 3.90 | 71.15 |

**Max Speed Test (w/DF-2 Fuel)**

| | FUEL RET psi | CLNT B4 RAD psi | CLNT AFT RAD psi | CLNT AFT T CLR | CLNT B4 AFT CLR | CLNT AFT AFT CLR | CLNT B4 PUMP p | CELL AMB T/L | CELL AMB B/L | CELL AMB T/R | CELL AMB B/R | AIR B4 INLET 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| 12/30/2003 | 0.73 | 14.58 | 8.96 | 184.44 | 103.66 | 106.85 | 8.59 | 78.42 | 77.79 | 78.17 | 77.56 | 83.88 |
| 12/30/2003 | 0.73 | 14.02 | 8.46 | 181.91 | 101.31 | 104.86 | 7.95 | 78.43 | 77.53 | 78.57 | 77.96 | 84.30 |
| 12/30/2003 | 0.76 | 13.82 | 8.39 | 185.46 | 103.38 | 107.24 | 7.88 | 78.80 | 77.63 | 79.15 | 78.03 | 84.66 |
| ***Configuration 3*** | | | | | | | | | | | | |
| 4/26/2004 | 1.38 | 17.20 | 8.48 | 177.48 | 180.21 | 189.67 | 9.46 | 80.24 | 82.26 | 79.85 | 78.89 | 79.83 |
| 4/26/2004 | 1.36 | 17.27 | 8.69 | 175.70 | 177.89 | 187.31 | 9.93 | 80.82 | 82.65 | 80.44 | 79.45 | 80.36 |
| 4/26/2004 | 1.35 | 18.01 | 9.51 | 181.30 | 189.80 | 193.82 | 10.58 | 81.11 | 82.96 | 80.85 | 79.92 | 80.89 |
| 4/26/2004 | 1.32 | 19.03 | 10.43 | 185.68 | 187.78 | 197.72 | 11.52 | 81.35 | 83.14 | 80.94 | 79.89 | 81.02 |

**Fuel Consumption**

| | FUEL RET psi | CLNT B4 RAD psi | CLNT AFT RAD psi | CLNT AFT T CLR | CLNT B4 AFT CLR | CLNT AFT AFT CLR | CLNT B4 PUMP p | CELL AMB T/L | CELL AMB B/L | CELL AMB T/R | CELL AMB B/R | AIR B4 INLET 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| DF-2, 10/15/03 | 1.47 | 9.26 | 6.41 | 159.61 | 96.59 | 93.29 | 5.93 | 88.76 | 88.37 | 84.32 | 83.66 | 87.79 |
| DF-2, 10/15/03 | 1.34 | 10.10 | 7.13 | 163.68 | 94.33 | 90.73 | 6.65 | 85.50 | 85.02 | 82.32 | 81.56 | 85.09 |
| JP-8, 10/09/03 | 1.13 | 10.53 | 7.12 | 160.20 | 91.85 | 88.97 | 6.73 | 84.15 | 84.20 | 81.83 | 81.50 | 83.32 |
| JP-8, 10/09/03 | 1.09 | 10.19 | 7.04 | 159.41 | 91.09 | 88.16 | 6.69 | 83.03 | 83.18 | 80.91 | 80.64 | 82.44 |
| ***Configuration 3*** | | | | | | | | | | | | |
| DF-2, 4/21/04 | 2.27 | 9.41 | 4.91 | 153.59 | 157.22 | 159.05 | 5.97 | 79.26 | 80.10 | 79.61 | 78.09 | 79.59 |
| DF-2, 4/22/04 | 2.21 | 9.60 | 5.06 | 157.99 | 162.14 | 164.64 | 6.32 | 80.14 | 81.62 | 78.91 | 77.91 | 79.53 |
| DF-2, 4/22/04 | 2.21 | 9.69 | 5.13 | 158.44 | 162.68 | 165.04 | 6.42 | 81.36 | 82.90 | 80.45 | 79.57 | 80.89 |
| JP-8, 4/27/04 | 1.98 | 12.51 | 7.86 | 161.24 | 172.33 | 168.15 | 9.20 | 80.17 | 79.04 | 80.16 | 79.30 | 80.05 |
| JP-8, 4/28/04 | 2.20 | 10.08 | 5.65 | 159.03 | 162.82 | 165.45 | 6.74 | 79.68 | 80.45 | 80.55 | 79.16 | 80.30 |
| JP-8, 4/28/04 | 2.20 | 10.36 | 5.90 | 161.25 | 165.14 | 167.70 | 7.05 | 80.96 | 81.58 | 81.86 | 80.47 | 81.68 |

**Mixer Data, 4/16/2004**

| | FUEL RET psi | CLNT B4 RAD psi | CLNT AFT RAD psi | CLNT AFT T CLR | CLNT B4 AFT CLR | CLNT AFT AFT CLR | CLNT B4 PUMP p | CELL AMB T/L | CELL AMB B/L | CELL AMB T/R | CELL AMB B/R | AIR B4 INLET 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 3*** | | | | | | | | | | | | |
| 0.33 | 1.83 | 21.20 | 13.65 | 220.40 | 227.25 | 233.30 | 14.73 | 105.55 | 106.02 | 105.37 | 104.97 | 108.64 |
| 0.35 | 1.89 | 19.70 | 12.90 | 218.74 | 224.64 | 231.02 | 14.14 | 105.54 | 106.00 | 105.36 | 104.96 | 108.96 |
| 0.37 | 2.15 | 17.33 | 11.82 | 214.81 | 220.70 | 225.90 | 13.31 | 105.58 | 105.97 | 105.54 | 104.98 | 109.33 |

**Max Speed Test (w/DF-2 Fuel)**

| | AIR B4 INLET 2 | AIR B4 INLET 3 | AIR B4 INLET 4 | AIR B4 INLET 5 | AIR B4 INLET 6 | AIR B4 INLET 7 | AIR AFT INLET 1 | AIR AFT INLET 2 | AIR AFT INLET 3 | AIR AFT INLET 4 | AIR AFT INLET 5 | AIR AFT INLET 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| 12/30/2003 | 85.10 | 85.78 | 96.68 | 91.38 | 93.92 | 100.04 | 95.41 | 84.53 | 85.56 | 96.63 | 90.87 | 93.98 |
| 12/30/2003 | 85.67 | 86.15 | 97.29 | 91.91 | 93.76 | 100.93 | 89.27 | 84.72 | 85.64 | 97.24 | 90.82 | 93.69 |
| 12/30/2003 | 86.31 | 87.73 | 99.15 | 92.57 | 94.92 | 102.28 | 92.17 | 85.23 | 87.11 | 99.06 | 91.73 | 94.60 |
| ***Configuration 3*** | | | | | | | | | | | | |
| 4/26/2004 | 79.69 | 80.06 | 80.42 | 80.50 | 80.90 | 80.70 | 80.78 | 79.36 | 79.20 | 80.02 | 80.66 | 80.89 |
| 4/26/2004 | 80.21 | 80.61 | 80.94 | 80.93 | 81.38 | 81.27 | 81.15 | 79.86 | 79.76 | 80.56 | 81.13 | 81.41 |
| 4/26/2004 | 80.67 | 81.14 | 81.40 | 81.44 | 81.85 | 81.67 | 81.55 | 80.27 | 80.29 | 81.05 | 81.70 | 81.90 |
| 4/26/2004 | 80.84 | 81.30 | 81.56 | 81.68 | 82.05 | 81.78 | 81.86 | 80.61 | 80.56 | 81.37 | 82.13 | 82.38 |

**Fuel Consumption**

| | AIR B4 INLET 2 | AIR B4 INLET 3 | AIR B4 INLET 4 | AIR B4 INLET 5 | AIR B4 INLET 6 | AIR B4 INLET 7 | AIR AFT INLET 1 | AIR AFT INLET 2 | AIR AFT INLET 3 | AIR AFT INLET 4 | AIR AFT INLET 5 | AIR AFT INLET 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| DF-2, 10/15/03 | 85.85 | 84.89 | 84.98 | 87.71 | 87.07 | 84.96 | 88.67 | 85.95 | 84.54 | 84.87 | 87.97 | 87.33 |
| DF-2, 10/15/03 | 83.32 | 82.85 | 83.13 | 85.25 | 85.04 | 83.32 | 85.65 | 83.32 | 82.37 | 82.90 | 85.41 | 84.87 |
| JP-8, 10/09/03 | 82.63 | 82.44 | 82.69 | 84.10 | 83.98 | 82.69 | 85.19 | 82.85 | 82.22 | 82.78 | 84.47 | 84.20 |
| JP-8, 10/09/03 | 81.77 | 81.48 | 81.74 | 83.10 | 83.04 | 81.82 | 84.59 | 82.01 | 81.39 | 81.92 | 83.58 | 83.23 |
| ***Configuration 3*** | | | | | | | | | | | | |
| DF-2, 4/21/04 | 78.61 | 79.09 | 79.35 | 79.13 | 79.76 | 79.38 | 80.25 | 78.14 | 78.04 | 78.54 | 78.82 | 78.82 |
| DF-2, 4/22/04 | 79.21 | 79.25 | 79.48 | 79.73 | 80.32 | 79.67 | 80.81 | 78.86 | 78.50 | 79.24 | 79.87 | 80.10 |
| DF-2, 4/22/04 | 80.61 | 80.75 | 80.95 | 81.00 | 81.57 | 81.07 | 81.65 | 80.35 | 80.13 | 80.77 | 81.22 | 81.42 |
| JP-8, 4/27/04 | 80.04 | 80.30 | 80.55 | 80.29 | 80.54 | 80.76 | 81.57 | 79.59 | 79.59 | 80.45 | 80.55 | 80.53 |
| JP-8, 4/28/04 | 79.44 | 80.10 | 80.32 | 79.50 | 80.01 | 80.35 | 79.54 | 78.81 | 79.03 | 79.54 | 79.29 | 79.23 |
| JP-8, 4/28/04 | 80.83 | 81.49 | 81.72 | 80.82 | 81.30 | 81.71 | 80.95 | 80.17 | 80.38 | 80.87 | 80.58 | 80.49 |

**Mixer Data, 4/16/2004**

| | AIR B4 INLET 2 | AIR B4 INLET 3 | AIR B4 INLET 4 | AIR B4 INLET 5 | AIR B4 INLET 6 | AIR B4 INLET 7 | AIR AFT INLET 1 | AIR AFT INLET 2 | AIR AFT INLET 3 | AIR AFT INLET 4 | AIR AFT INLET 5 | AIR AFT INLET 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 3*** | | | | | | | | | | | | |
| 0.33 | 109.99 | 108.86 | 109.39 | 107.05 | 107.87 | 109.03 | 125.99 | 106.27 | 106.00 | 106.17 | 107.49 | 107.75 |
| 0.35 | 110.35 | 109.14 | 109.63 | 107.23 | 108.11 | 109.27 | 127.49 | 106.30 | 106.03 | 106.28 | 107.58 | 107.86 |
| 0.37 | 110.90 | 109.72 | 110.34 | 107.48 | 108.70 | 110.02 | 128.60 | 106.52 | 106.43 | 106.91 | 107.71 | 108.18 |

**Max Speed Test (w/DF-2 Fuel)**

| | AIR AFT INLET 7 | AIR >FAN L/1 f | AIR >FAN L/2 f | AIR >FAN L/3 f | AIR >FAN L/4 f | AIR >FAN R/1 f | AIR >FAN R/2 f | AIR >FAN R/3 f | AIR >FAN R/4 f | AIR B4 RAD 1 f | AIR B4 RAD 2 f | AIR B4 RAD 3 f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| 12/30/2003 | 99.63 | 82.76 | 93.65 | 130.26 | 97.04 | 116.05 | 113.12 | 112.01 | 110.73 | 108.41 | 114.03 | 135.76 |
| 12/30/2003 | 100.85 | 83.39 | 93.85 | 129.92 | 97.65 | 117.04 | 114.44 | 110.51 | 111.30 | 109.15 | 113.79 | 136.98 |
| 12/30/2003 | 101.98 | 84.54 | 95.36 | 132.62 | 99.25 | 119.06 | 115.18 | 112.26 | 113.48 | 110.94 | 115.54 | 139.97 |
| ***Configuration 3*** | | | | | | | | | | | | |
| 4/26/2004 | 80.53 | 80.22 | 89.69 | 124.47 | 89.97 | 102.19 | 84.40 | 101.67 | 113.07 | 103.79 | 112.87 | 126.90 |
| 4/26/2004 | 81.14 | 81.09 | 89.85 | 125.06 | 91.49 | 102.38 | 85.38 | 100.82 | 113.71 | 104.24 | 112.63 | 129.21 |
| 4/26/2004 | 81.56 | 81.68 | 91.11 | 127.47 | 94.30 | 104.79 | 86.03 | 103.13 | 116.22 | 105.85 | 115.00 | 131.74 |
| 4/26/2004 | 81.95 | 82.06 | 108.89 | 129.80 | 97.05 | 97.28 | 86.37 | 113.69 | 102.64 | 125.80 | 114.78 | 137.54 |

**Fuel Consumption**

| | AIR AFT INLET 7 | AIR >FAN L/1 f | AIR >FAN L/2 f | AIR >FAN L/3 f | AIR >FAN L/4 f | AIR >FAN R/1 f | AIR >FAN R/2 f | AIR >FAN R/3 f | AIR >FAN R/4 f | AIR B4 RAD 1 f | AIR B4 RAD 2 f | AIR B4 RAD 3 f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| DF-2, 10/15/03 | 85.07 | 85.77 | 88.78 | 118.22 | 100.48 | 99.05 | 96.23 | 103.84 | 101.93 | 105.58 | 108.18 | 126.40 |
| DF-2, 10/15/03 | 83.30 | 83.75 | 86.90 | 119.57 | 100.16 | 99.75 | 95.36 | 103.47 | 101.24 | 105.73 | 107.49 | 129.13 |
| JP-8, 10/09/03 | 83.17 | 83.50 | 86.37 | 119.45 | 99.58 | 98.21 | 94.62 | 102.27 | 101.48 | 104.39 | 106.51 | 127.92 |
| JP-8, 10/09/03 | 82.25 | 82.71 | 85.55 | 118.72 | 99.19 | 97.74 | 93.59 | 101.75 | 100.49 | 103.69 | 105.70 | 127.42 |
| ***Configuration 3*** | | | | | | | | | | | | |
| DF-2, 4/21/04 | 78.78 | 79.58 | 88.39 | 119.27 | 88.85 | 96.57 | 83.53 | 97.97 | 104.92 | 94.17 | 104.47 | 118.79 |
| DF-2, 4/22/04 | 79.64 | 80.03 | 89.84 | 122.89 | 91.37 | 98.71 | 84.60 | 100.16 | 107.90 | 96.13 | 106.81 | 123.19 |
| DF-2, 4/22/04 | 81.08 | 81.55 | 91.01 | 123.95 | 92.83 | 99.99 | 85.97 | 101.23 | 108.99 | 97.34 | 107.98 | 124.39 |
| JP-8, 4/27/04 | 80.70 | 80.97 | 102.66 | 123.74 | 91.62 | 113.45 | 83.22 | 103.65 | 108.12 | 97.73 | 106.56 | 123.81 |
| JP-8, 4/28/04 | 79.68 | 80.53 | 101.75 | 121.27 | 89.91 | 111.69 | 82.63 | 101.91 | 106.15 | 97.19 | 105.05 | 121.95 |
| JP-8, 4/28/04 | 81.00 | 82.03 | 103.66 | 123.73 | 92.26 | 113.97 | 84.05 | 103.59 | 107.98 | 98.96 | 107.08 | 125.00 |

**Mixer Data, 4/16/2004**

| | AIR AFT INLET 7 | AIR >FAN L/1 f | AIR >FAN L/2 f | AIR >FAN L/3 f | AIR >FAN L/4 f | AIR >FAN R/1 f | AIR >FAN R/2 f | AIR >FAN R/3 f | AIR >FAN R/4 f | AIR B4 RAD 1 f | AIR B4 RAD 2 f | AIR B4 RAD 3 f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 3*** | | | | | | | | | | | | |
| 0.33 | 106.75 | 107.37 | 125.41 | 163.76 | 122.35 | 136.79 | 112.33 | 132.70 | 148.43 | 133.03 | 143.80 | 165.43 |
| 0.35 | 106.80 | 107.58 | 125.29 | 164.13 | 123.05 | 138.10 | 112.49 | 133.77 | 148.45 | 132.06 | 143.34 | 165.26 |
| 0.37 | 107.50 | 108.13 | 123.41 | 164.28 | 123.76 | 139.38 | 113.00 | 135.79 | 148.32 | 129.58 | 142.10 | 163.40 |

**Max Speed Test (w/DF-2 Fuel)**

| | AIR AFT INLET 7 | AIR >FAN L/1 f | AIR >FAN L/2 f | AIR >FAN L/3 f | AIR >FAN L/4 f | AIR >FAN R/1 f | AIR >FAN R/2 f | AIR >FAN R/3 f | AIR >FAN R/4 f | AIR B4 RAD 1 f | AIR B4 RAD 2 f | AIR B4 RAD 3 f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| 12/30/2003 | 99.63 | 82.76 | 93.65 | 130.26 | 97.04 | 116.05 | 113.12 | 112.01 | 110.73 | 108.41 | 114.03 | 135.76 |
| 12/30/2003 | 100.85 | 83.39 | 93.85 | 129.92 | 97.65 | 117.04 | 114.44 | 110.51 | 111.30 | 109.15 | 113.79 | 136.98 |
| 12/30/2003 | 101.98 | 84.54 | 95.36 | 132.62 | 99.25 | 119.06 | 115.18 | 112.26 | 113.48 | 110.94 | 115.54 | 139.97 |
| ***Configuration 3*** | | | | | | | | | | | | |
| 4/26/2004 | 80.53 | 80.22 | 89.69 | 124.47 | 89.97 | 102.19 | 84.40 | 101.67 | 113.07 | 103.79 | 112.87 | 126.90 |
| 4/26/2004 | 81.14 | 81.09 | 89.85 | 125.06 | 91.49 | 102.38 | 85.38 | 100.82 | 113.71 | 104.24 | 112.63 | 129.21 |
| 4/26/2004 | 81.56 | 81.68 | 91.11 | 127.47 | 94.30 | 104.79 | 86.03 | 103.13 | 116.22 | 105.85 | 115.00 | 131.74 |
| 4/26/2004 | 81.95 | 82.06 | 108.89 | 129.80 | 97.05 | 97.28 | 86.37 | 113.69 | 102.64 | 125.80 | 114.78 | 137.54 |

**Fuel Consumption**

| | AIR AFT INLET 7 | AIR >FAN L/1 f | AIR >FAN L/2 f | AIR >FAN L/3 f | AIR >FAN L/4 f | AIR >FAN R/1 f | AIR >FAN R/2 f | AIR >FAN R/3 f | AIR >FAN R/4 f | AIR B4 RAD 1 f | AIR B4 RAD 2 f | AIR B4 RAD 3 f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| DF-2, 10/15/03 | 85.07 | 85.77 | 88.78 | 118.22 | 100.48 | 99.05 | 96.23 | 103.84 | 101.93 | 105.58 | 108.18 | 126.40 |
| DF-2, 10/15/03 | 83.30 | 83.75 | 86.90 | 119.57 | 100.16 | 99.75 | 95.36 | 103.47 | 101.24 | 105.73 | 107.49 | 129.13 |
| JP-8, 10/09/03 | 83.17 | 83.50 | 86.37 | 119.45 | 99.58 | 98.21 | 94.62 | 102.27 | 101.48 | 104.39 | 106.51 | 127.92 |
| JP-8, 10/09/03 | 82.25 | 82.71 | 85.55 | 118.72 | 99.19 | 97.74 | 93.59 | 101.75 | 100.49 | 103.69 | 105.70 | 127.42 |
| ***Configuration 3*** | | | | | | | | | | | | |
| DF-2, 4/21/04 | 78.78 | 79.58 | 88.39 | 119.27 | 88.85 | 96.57 | 83.53 | 97.97 | 104.92 | 94.17 | 104.47 | 118.79 |
| DF-2, 4/22/04 | 79.64 | 80.03 | 89.84 | 122.89 | 91.37 | 98.71 | 84.60 | 100.16 | 107.90 | 96.13 | 106.81 | 123.19 |
| DF-2, 4/22/04 | 81.08 | 81.55 | 91.01 | 123.95 | 92.83 | 99.99 | 85.97 | 101.23 | 108.99 | 97.34 | 107.98 | 124.39 |
| JP-8, 4/27/04 | 80.70 | 80.97 | 102.66 | 123.74 | 91.62 | 113.45 | 83.22 | 103.65 | 108.12 | 97.73 | 106.56 | 123.81 |
| JP-8, 4/28/04 | 79.68 | 80.53 | 101.75 | 121.27 | 89.91 | 111.69 | 82.63 | 101.91 | 106.15 | 97.19 | 105.05 | 121.95 |
| JP-8, 4/28/04 | 81.00 | 82.03 | 103.66 | 123.73 | 92.26 | 113.97 | 84.05 | 103.59 | 107.98 | 98.96 | 107.08 | 125.00 |

**Mixer Data, 4/16/2004**

| | AIR AFT INLET 7 | AIR >FAN L/1 f | AIR >FAN L/2 f | AIR >FAN L/3 f | AIR >FAN L/4 f | AIR >FAN R/1 f | AIR >FAN R/2 f | AIR >FAN R/3 f | AIR >FAN R/4 f | AIR B4 RAD 1 f | AIR B4 RAD 2 f | AIR B4 RAD 3 f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 3*** | | | | | | | | | | | | |
| 0.33 | 106.75 | 107.37 | 125.41 | 163.76 | 122.35 | 136.79 | 112.33 | 132.70 | 148.43 | 133.03 | 143.80 | 165.43 |
| 0.35 | 106.80 | 107.58 | 125.29 | 164.13 | 123.05 | 138.10 | 112.49 | 133.77 | 148.45 | 132.06 | 143.34 | 165.26 |
| 0.37 | 107.50 | 108.13 | 123.41 | 164.28 | 123.76 | 139.38 | 113.00 | 135.79 | 148.32 | 129.58 | 142.10 | 163.40 |

**Max Speed Test (w/DF-2 Fuel)**

| | AIR B4 RAD 4 f | AIR B4 RAD 5 f | AIR B4 RAD 6 f | AIR B4 RAD 7 f | AIR B4 RAD 8 f | AIR B4 RAD 9 f | AIR B4 RAD 10 f | AIR AFT RAD 1 f | AIR AFT RAD 2 f | AIR AFT RAD 3 f | AIR AFT RAD 4 f | AIR AFT RAD 5 f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| 12/30/2003 | 100.50 | 114.75 | 128.75 | 121.85 | 114.91 | 121.12 | 128.98 | 146.82 | 162.39 | 151.76 | 131.64 | 139.25 |
| 12/30/2003 | 100.75 | 116.21 | 129.09 | 121.37 | 115.49 | 121.79 | 129.47 | 145.97 | 160.87 | 150.83 | 130.66 | 138.53 |
| 12/30/2003 | 102.08 | 117.24 | 131.01 | 123.12 | 117.32 | 124.00 | 132.04 | 148.99 | 164.25 | 153.81 | 132.88 | 140.93 |
| ***Configuration 3*** | | | | | | | | | | | | |
| 4/26/2004 | 97.40 | 102.10 | 112.93 | 110.46 | 106.37 | 114.51 | 120.31 | 143.15 | 158.80 | 148.63 | 132.23 | 128.54 |
| 4/26/2004 | 97.87 | 102.41 | 112.60 | 110.03 | 106.42 | 114.99 | 120.75 | 142.53 | 157.68 | 148.87 | 132.07 | 127.99 |
| 4/26/2004 | 100.74 | 103.94 | 114.42 | 112.05 | 108.16 | 117.14 | 124.73 | 146.50 | 163.98 | 153.03 | 135.76 | 131.38 |
| 4/26/2004 | 102.26 | 100.49 | 116.05 | 117.02 | 120.67 | 120.47 | 129.36 | 155.89 | 167.51 | 156.67 | 138.99 | 136.77 |

**Fuel Consumption**

| | AIR B4 RAD 4 f | AIR B4 RAD 5 f | AIR B4 RAD 6 f | AIR B4 RAD 7 f | AIR B4 RAD 8 f | AIR B4 RAD 9 f | AIR B4 RAD 10 f | AIR AFT RAD 1 f | AIR AFT RAD 2 f | AIR AFT RAD 3 f | AIR AFT RAD 4 f | AIR AFT RAD 5 f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| DF-2, 10/15/03 | 99.80 | 95.71 | 107.15 | 108.56 | 97.84 | 105.34 | 111.31 | 138.89 | 146.87 | 138.88 | 127.48 | 127.51 |
| DF-2, 10/15/03 | 98.45 | 95.31 | 106.55 | 108.14 | 96.83 | 105.10 | 111.73 | 141.83 | 150.41 | 142.45 | 129.66 | 130.11 |
| JP-8, 10/09/03 | 97.29 | 94.51 | 105.92 | 106.22 | 96.43 | 103.02 | 110.89 | 140.33 | 148.21 | 138.35 | 127.86 | 128.81 |
| JP-8, 10/09/03 | 96.54 | 94.01 | 105.30 | 105.48 | 95.49 | 102.03 | 110.02 | 139.46 | 147.38 | 138.06 | 127.37 | 128.21 |
| ***Configuration 3*** | | | | | | | | | | | | |
| DF-2, 4/21/04 | 92.81 | 91.78 | 101.41 | 101.13 | 94.57 | 101.14 | 108.19 | 130.57 | 142.59 | 134.74 | 123.02 | 121.11 |
| DF-2, 4/22/04 | 95.11 | 92.92 | 103.72 | 102.77 | 96.98 | 102.67 | 111.51 | 134.60 | 147.54 | 141.14 | 126.29 | 121.75 |
| DF-2, 4/22/04 | 96.51 | 94.37 | 104.81 | 103.88 | 98.16 | 103.90 | 112.54 | 135.38 | 148.07 | 141.68 | 126.98 | 122.32 |
| JP-8, 4/27/04 | 97.30 | 93.46 | 104.97 | 103.45 | 95.94 | 103.66 | 113.29 | 137.46 | 150.52 | 143.61 | 129.14 | 127.02 |
| JP-8, 4/28/04 | 94.68 | 91.85 | 103.19 | 102.46 | 94.23 | 103.02 | 110.50 | 135.20 | 146.99 | 138.78 | 127.26 | 128.11 |
| JP-8, 4/28/04 | 97.08 | 93.70 | 104.86 | 104.23 | 96.12 | 104.77 | 112.59 | 137.44 | 149.34 | 141.43 | 129.45 | 129.54 |

**Mixer Data, 4/16/2004**

| | AIR B4 RAD 4 f | AIR B4 RAD 5 f | AIR B4 RAD 6 f | AIR B4 RAD 7 f | AIR B4 RAD 8 f | AIR B4 RAD 9 f | AIR B4 RAD 10 f | AIR AFT RAD 1 f | AIR AFT RAD 2 f | AIR AFT RAD 3 f | AIR AFT RAD 4 f | AIR AFT RAD 5 f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 3*** | | | | | | | | | | | | |
| 0.33 | 129.24 | 130.75 | 142.39 | 140.26 | 135.66 | 146.85 | 155.32 | 182.44 | 201.45 | 185.43 | 167.65 | 161.28 |
| 0.35 | 129.83 | 129.89 | 141.50 | 139.70 | 134.55 | 145.65 | 154.40 | 182.81 | 201.15 | 185.42 | 168.08 | 161.82 |
| 0.37 | 131.45 | 128.16 | 139.57 | 138.64 | 131.90 | 143.11 | 152.25 | 183.12 | 200.26 | 184.71 | 169.08 | 163.05 |

**Max Speed Test (w/DF-2 Fuel)**

| | AIR AFT RAD 6 f | AIR AFT RAD 7 f | AIR AFT RAD 8 f | AIR AFT RAD 9 f | AIR AFT RAD 10 f | AIR B4 EX GR 1 | AIR B4 EX GR 2 | AIR B4 EX GR 3 | AIR B4 EX GR 4 | AIR B4 EX GR 5 | AIR B4 EX GR 6 | AIR AFT EX GR 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| 12/30/2003 | 145.96 | 140.25 | 143.33 | 146.73 | 155.47 | 140.67 | 145.85 | 162.89 | 153.50 | 158.03 | 163.44 | 148.51 |
| 12/30/2003 | 144.42 | 138.77 | 142.32 | 145.57 | 154.07 | 139.66 | 144.80 | 160.78 | 151.89 | 156.53 | 161.25 | 147.52 |
| 12/30/2003 | 147.14 | 141.54 | 145.04 | 148.41 | 157.13 | 142.39 | 147.76 | 164.23 | 154.94 | 159.52 | 164.49 | 150.36 |
| ***Configuration 3*** | | | | | | | | | | | | |
| 4/26/2004 | 138.45 | 131.96 | 138.82 | 144.12 | 138.27 | 140.88 | 142.34 | 160.83 | 153.07 | 143.91 | 158.66 | 144.60 |
| 4/26/2004 | 137.67 | 131.46 | 138.06 | 143.23 | 138.61 | 140.48 | 141.81 | 159.20 | 151.95 | 142.95 | 157.32 | 144.39 |
| 4/26/2004 | 141.64 | 135.25 | 141.96 | 147.35 | 142.64 | 144.70 | 145.95 | 164.60 | 156.70 | 147.19 | 162.36 | 148.56 |
| 4/26/2004 | 147.91 | 143.27 | 150.12 | 152.75 | 152.95 | 150.25 | 146.63 | 167.19 | 163.71 | 151.85 | 171.30 | 153.63 |

**Fuel Consumption**

| | AIR AFT RAD 6 f | AIR AFT RAD 7 f | AIR AFT RAD 8 f | AIR AFT RAD 9 f | AIR AFT RAD 10 f | AIR B4 EX GR 1 | AIR B4 EX GR 2 | AIR B4 EX GR 3 | AIR B4 EX GR 4 | AIR B4 EX GR 5 | AIR B4 EX GR 6 | AIR AFT EX GR 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| DF-2, 10/15/03 | 134.59 | 130.05 | 128.32 | 133.77 | 141.48 | 132.34 | 138.76 | 145.93 | 140.12 | 139.19 | 148.91 | 138.02 |
| DF-2, 10/15/03 | 137.38 | 132.74 | 130.75 | 136.64 | 144.92 | 134.47 | 141.63 | 149.30 | 142.98 | 142.06 | 152.47 | 140.52 |
| JP-8, 10/09/03 | 135.44 | 132.85 | 128.80 | 134.79 | 142.14 | 133.28 | 139.99 | 147.69 | 141.14 | 140.47 | 150.49 | 137.98 |
| JP-8, 10/09/03 | 134.87 | 132.38 | 128.22 | 134.18 | 141.68 | 132.38 | 139.11 | 146.75 | 140.18 | 139.50 | 149.61 | 137.27 |
| ***Configuration 3*** | | | | | | | | | | | | |
| DF-2, 4/21/04 | 128.48 | 122.44 | 126.33 | 130.10 | 127.79 | 128.92 | 132.61 | 142.43 | 138.57 | 132.65 | 143.21 | 132.92 |
| DF-2, 4/22/04 | 131.56 | 125.56 | 129.55 | 133.40 | 130.95 | 132.59 | 136.30 | 147.35 | 142.44 | 136.50 | 147.34 | 136.36 |
| DF-2, 4/22/04 | 132.05 | 126.07 | 130.13 | 133.91 | 131.65 | 133.33 | 137.19 | 148.01 | 143.18 | 137.35 | 148.01 | 137.04 |
| JP-8, 4/27/04 | 137.03 | 129.59 | 131.95 | 136.43 | 134.87 | 135.46 | 138.27 | 149.85 | 145.01 | 141.43 | 151.31 | 139.57 |
| JP-8, 4/28/04 | 135.34 | 127.82 | 130.36 | 134.77 | 133.78 | 133.48 | 136.15 | 146.80 | 142.80 | 139.04 | 149.14 | 137.82 |
| JP-8, 4/28/04 | 137.24 | 129.68 | 132.30 | 136.69 | 135.80 | 135.50 | 138.51 | 149.11 | 145.04 | 141.20 | 151.37 | 139.83 |

**Mixer Data, 4/16/2004**

| | AIR AFT RAD 6 f | AIR AFT RAD 7 f | AIR AFT RAD 8 f | AIR AFT RAD 9 f | AIR AFT RAD 10 f | AIR B4 EX GR 1 | AIR B4 EX GR 2 | AIR B4 EX GR 3 | AIR B4 EX GR 4 | AIR B4 EX GR 5 | AIR B4 EX GR 6 | AIR AFT EX GR 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 3*** | | | | | | | | | | | | |
| 0.33 | 173.88 | 167.17 | 174.64 | 179.47 | 173.57 | 180.56 | 182.36 | 202.04 | 194.05 | 183.71 | 200.08 | 189.50 |
| 0.35 | 174.21 | 167.53 | 174.45 | 179.22 | 173.50 | 180.61 | 183.05 | 201.37 | 194.07 | 184.35 | 200.24 | 189.62 |
| 0.37 | 175.24 | 168.34 | 174.10 | 178.49 | 172.75 | 180.58 | 184.48 | 199.93 | 193.78 | 185.94 | 200.41 | 189.24 |

**Max Speed Test (w/DF-2 Fuel)**

| | AIR AFT EX GR 2 | AIR AFT EX GR 3 | AIR AFT EX GR 4 | AIR AFT EX GR 5 | AIR AFT EX GR 6 | AIR B4 IN GR p1 | AIR B4 IN GR p2 | AIR B4 IN GR p3 | AIR B4 IN GR p4 | AIR B4 IN GR p5 | AIR B4 IN GR p6 | AIR B4 IN GR p7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Configuration 1* | | | | | | | | | | | | |
| 12/30/2003 | 152.54 | 164.34 | 157.28 | 156.73 | 165.86 | -0.36 | -0.50 | -0.52 | -0.53 | -0.27 | -0.34 | -0.59 |
| 12/30/2003 | 151.59 | 162.62 | 155.69 | 155.62 | 163.80 | -0.36 | -0.50 | -0.51 | -0.53 | -0.28 | -0.34 | -0.59 |
| 12/30/2003 | 154.97 | 165.97 | 158.88 | 158.58 | 167.21 | -0.35 | -0.50 | -0.50 | -0.52 | -0.28 | -0.33 | -0.58 |
| *Configuration 3* | | | | | | | | | | | | |
| 4/26/2004 | 142.42 | 161.67 | 155.94 | 144.30 | 160.56 | -0.36 | -0.57 | -0.60 | -0.47 | -0.24 | -0.27 | -0.57 |
| 4/26/2004 | 141.79 | 160.49 | 154.84 | 143.44 | 159.11 | -0.35 | -0.56 | -0.59 | -0.47 | -0.24 | -0.27 | -0.56 |
| 4/26/2004 | 145.82 | 165.42 | 159.74 | 147.56 | 164.30 | -0.34 | -0.55 | -0.58 | -0.46 | -0.24 | -0.26 | -0.55 |
| 4/26/2004 | 146.33 | 168.72 | 165.65 | 152.57 | 172.69 | -0.27 | -0.51 | -0.52 | -0.38 | -0.19 | -0.19 | -0.43 |

**Fuel Consumption**

| | AIR AFT EX GR 2 | AIR AFT EX GR 3 | AIR AFT EX GR 4 | AIR AFT EX GR 5 | AIR AFT EX GR 6 | AIR B4 IN GR p1 | AIR B4 IN GR p2 | AIR B4 IN GR p3 | AIR B4 IN GR p4 | AIR B4 IN GR p5 | AIR B4 IN GR p6 | AIR B4 IN GR p7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Configuration 1* | | | | | | | | | | | | |
| DF-2, 10/15/03 | 141.13 | 147.52 | 143.28 | 139.52 | 151.30 | -0.23 | -0.36 | -0.30 | -0.36 | -0.28 | -0.32 | -0.34 |
| DF-2, 10/15/03 | 144.00 | 150.70 | 146.11 | 142.08 | 154.75 | -0.24 | -0.36 | -0.30 | -0.36 | -0.28 | -0.32 | -0.36 |
| JP-8, 10/09/03 | 141.18 | 147.77 | 143.51 | 139.83 | 151.54 | -0.21 | -0.30 | -0.33 | -0.32 | -0.24 | -0.28 | -0.35 |
| JP-8, 10/09/03 | 140.54 | 146.95 | 142.71 | 139.01 | 150.83 | -0.22 | -0.29 | -0.33 | -0.32 | -0.24 | -0.28 | -0.34 |
| *Configuration 3* | | | | | | | | | | | | |
| DF-2, 4/21/04 | 133.78 | 145.24 | 142.01 | 134.38 | 145.98 | -0.19 | -0.44 | -0.36 | -0.31 | -0.17 | -0.17 | -0.38 |
| DF-2, 4/22/04 | 137.20 | 149.14 | 145.95 | 137.77 | 149.80 | -0.16 | -0.40 | -0.35 | -0.27 | -0.14 | -0.13 | -0.34 |
| DF-2, 4/22/04 | 137.89 | 149.74 | 146.54 | 138.38 | 150.24 | -0.16 | -0.40 | -0.34 | -0.27 | -0.14 | -0.13 | -0.34 |
| JP-8, 4/27/04 | 139.66 | 152.14 | 148.58 | 142.62 | 154.20 | -0.13 | -0.39 | -0.32 | -0.26 | -0.13 | -0.10 | -0.32 |
| JP-8, 4/28/04 | 137.41 | 150.06 | 146.20 | 140.54 | 152.17 | -0.18 | -0.43 | -0.37 | -0.29 | -0.16 | -0.14 | -0.39 |
| JP-8, 4/28/04 | 139.72 | 152.32 | 148.53 | 142.67 | 154.40 | -0.17 | -0.43 | -0.36 | -0.30 | -0.16 | -0.14 | -0.38 |

**Mixer Data, 4/16/2004**

| | AIR AFT EX GR 2 | AIR AFT EX GR 3 | AIR AFT EX GR 4 | AIR AFT EX GR 5 | AIR AFT EX GR 6 | AIR B4 IN GR p1 | AIR B4 IN GR p2 | AIR B4 IN GR p3 | AIR B4 IN GR p4 | AIR B4 IN GR p5 | AIR B4 IN GR p6 | AIR B4 IN GR p7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Configuration 3* | | | | | | | | | | | | |
| 0.33 | 185.58 | 206.65 | 201.02 | 187.18 | 205.06 | -0.15 | -0.62 | -0.22 | -0.43 | -0.23 | -0.22 | -0.29 |
| 0.35 | 186.37 | 206.24 | 201.20 | 188.00 | 205.25 | -0.11 | -0.59 | -0.21 | -0.39 | -0.22 | -0.20 | -0.24 |
| 0.37 | 188.07 | 205.20 | 200.66 | 189.99 | 205.51 | -0.05 | -0.53 | -0.14 | -0.32 | -0.18 | -0.16 | -0.17 |

**Max Speed Test (w/DF-2 Fuel)**

| | AIR AFT IN TP6 | AIR AFT IN TP7 | AIR B4 FAN L/p1 | AIR B4 FAN L/p2 | AIR B4 FAN L/p3 | AIR B4 FAN L/p4 | AIR B4 FAN R/p1 | AIR B4 FAN R/p2 | AIR B4 FAN R/p3 | AIR B4 FAN R/p4 | AIR B4 FAN LTP1 | AIR B4 FAN LTP2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| 12/30/2003 | -0.45 | -0.89 | -5.33 | -5.18 | -6.72 | -3.97 | -5.66 | -4.44 | -7.35 | -5.41 | -1.83 | -3.16 |
| 12/30/2003 | -0.47 | -0.89 | -5.39 | -5.25 | -6.80 | -4.01 | -5.72 | -4.55 | -7.43 | -5.44 | -1.86 | -3.18 |
| 12/30/2003 | -0.45 | -0.88 | -5.26 | -5.12 | -6.62 | -3.93 | -5.57 | -4.39 | -7.24 | -5.30 | -1.81 | -3.11 |
| ***Configuration 3*** | | | | | | | | | | | | |
| 4/26/2004 | 0.10 | -1.05 | -6.23 | -5.64 | -6.77 | -3.65 | -6.32 | -4.76 | -7.23 | -1.69 | -1.81 | -8.57 |
| 4/26/2004 | 0.11 | -1.03 | -6.06 | -5.50 | -6.50 | -3.57 | -6.18 | -4.65 | -7.11 | -1.60 | -1.78 | -8.38 |
| 4/26/2004 | 0.12 | -1.01 | -5.92 | -5.44 | -6.30 | -3.52 | -6.09 | -4.58 | -6.97 | -1.47 | -1.79 | -8.24 |
| 4/26/2004 | 0.27 | -0.73 | -5.70 | -5.60 | -6.46 | -3.35 | -4.45 | -3.37 | -5.90 | 1.31 | -1.61 | -9.31 |

**Fuel Consumption**

| | AIR AFT IN TP6 | AIR AFT IN TP7 | AIR B4 FAN L/p1 | AIR B4 FAN L/p2 | AIR B4 FAN L/p3 | AIR B4 FAN L/p4 | AIR B4 FAN R/p1 | AIR B4 FAN R/p2 | AIR B4 FAN R/p3 | AIR B4 FAN R/p4 | AIR B4 FAN LTP1 | AIR B4 FAN LTP2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| DF-2, 10/15/03 | -0.25 | -0.46 | -3.96 | -2.29 | -2.62 | -2.21 | -1.09 | -1.96 | -3.06 | -2.37 | -0.83 | -1.17 |
| DF-2, 10/15/03 | -0.25 | -0.45 | -3.97 | -2.29 | -2.62 | -2.20 | -1.10 | -1.96 | -3.01 | -2.36 | -0.83 | -1.19 |
| JP-8, 10/09/03 | -0.24 | -0.47 | -3.97 | -2.29 | -2.62 | -2.23 | -1.07 | -1.96 | -3.13 | -2.37 | -0.87 | -1.18 |
| JP-8, 10/09/03 | -0.24 | -0.48 | -3.95 | -2.27 | -2.59 | -2.23 | -1.06 | -1.95 | -3.13 | -2.35 | -0.86 | -1.18 |
| ***Configuration 3*** | | | | | | | | | | | | |
| DF-2, 4/21/04 | 0.37 | -0.39 | -2.52 | -2.18 | -1.60 | -1.70 | -2.62 | -1.72 | -2.89 | | -0.98 | -3.41 |
| DF-2, 4/22/04 | 0.42 | -0.39 | -2.57 | -2.21 | -1.59 | -1.74 | -2.68 | -1.72 | -2.99 | | -0.97 | -3.48 |
| DF-2, 4/22/04 | 0.42 | -0.39 | -2.55 | -2.20 | -1.76 | -1.73 | -2.66 | -1.71 | -2.86 | | -0.97 | -3.44 |
| JP-8, 4/27/04 | 0.46 | -0.40 | -2.62 | -2.10 | -1.88 | -1.70 | -2.29 | -1.26 | -2.11 | 2.05 | -0.98 | -3.38 |
| JP-8, 4/28/04 | 0.41 | -0.47 | -2.63 | -2.11 | -1.97 | -1.70 | -2.30 | -1.27 | -2.14 | 1.20 | -1.01 | -3.43 |
| JP-8, 4/28/04 | 0.40 | -0.47 | -2.62 | -2.11 | -1.95 | -1.70 | -2.30 | -1.28 | -2.16 | 0.89 | -1.01 | -3.39 |

**Mixer Data, 4/16/2004**

| | AIR AFT IN TP6 | AIR AFT IN TP7 | AIR B4 FAN L/p1 | AIR B4 FAN L/p2 | AIR B4 FAN L/p3 | AIR B4 FAN L/p4 | AIR B4 FAN R/p1 | AIR B4 FAN R/p2 | AIR B4 FAN R/p3 | AIR B4 FAN R/p4 | AIR B4 FAN LTP1 | AIR B4 FAN LTP2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 3*** | | | | | | | | | | | | |
| 0.33 | 0.09 | -1.03 | -4.75 | -4.32 | -6.18 | -2.97 | -4.94 | -3.70 | -5.68 | | -1.43 | -6.04 |
| 0.35 | 0.15 | -0.86 | -4.05 | -3.67 | -3.91 | -2.59 | -4.22 | -3.12 | -4.82 | | -1.26 | -5.10 |
| 0.37 | 0.26 | -0.59 | -2.90 | -2.61 | -2.09 | -1.97 | -3.01 | -2.17 | -3.42 | | -1.01 | -3.62 |

**Max Speed Test (w/DF-2 Fuel)**

| | AIR AFT IN TP6 | AIR AFT IN TP7 | AIR B4 FAN L/p1 | AIR B4 FAN L/p2 | AIR B4 FAN L/p3 | AIR B4 FAN L/p4 | AIR B4 FAN R/p1 | AIR B4 FAN R/p2 | AIR B4 FAN R/p3 | AIR B4 FAN R/p4 | AIR B4 FAN LTP1 | AIR B4 FAN LTP2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Configuration 1* | | | | | | | | | | | | |
| 12/30/2003 | -0.45 | -0.89 | -5.33 | -5.18 | -6.72 | -3.97 | -5.66 | -4.44 | -7.35 | -5.41 | -1.83 | -3.16 |
| 12/30/2003 | -0.47 | -0.89 | -5.39 | -5.25 | -6.80 | -4.01 | -5.72 | -4.55 | -7.43 | -5.44 | -1.86 | -3.18 |
| 12/30/2003 | -0.45 | -0.88 | -5.26 | -5.12 | -6.62 | -3.93 | -5.57 | -4.39 | -7.24 | -5.30 | -1.81 | -3.11 |
| *Configuration 3* | | | | | | | | | | | | |
| 4/26/2004 | 0.10 | -1.05 | -6.23 | -5.64 | -6.77 | -3.65 | -6.32 | -4.76 | -7.23 | -1.69 | -1.81 | -8.57 |
| 4/26/2004 | 0.11 | -1.03 | -6.06 | -5.50 | -6.50 | -3.57 | -6.18 | -4.65 | -7.11 | -1.60 | -1.78 | -8.38 |
| 4/26/2004 | 0.12 | -1.01 | -5.92 | -5.44 | -6.30 | -3.52 | -6.09 | -4.58 | -6.97 | -1.47 | -1.79 | -8.24 |
| 4/26/2004 | 0.27 | -0.73 | -5.70 | -5.60 | -6.46 | -3.35 | -4.45 | -3.37 | -5.90 | 1.31 | -1.61 | -9.31 |

**Fuel Consumption**

| | AIR AFT IN TP6 | AIR AFT IN TP7 | AIR B4 FAN L/p1 | AIR B4 FAN L/p2 | AIR B4 FAN L/p3 | AIR B4 FAN L/p4 | AIR B4 FAN R/p1 | AIR B4 FAN R/p2 | AIR B4 FAN R/p3 | AIR B4 FAN R/p4 | AIR B4 FAN LTP1 | AIR B4 FAN LTP2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Configuration 1* | | | | | | | | | | | | |
| DF-2, 10/15/03 | -0.25 | -0.46 | -3.96 | -2.29 | -2.62 | -2.21 | -1.09 | -1.96 | -3.06 | -2.37 | -0.83 | -1.17 |
| DF-2, 10/15/03 | -0.25 | -0.45 | -3.97 | -2.29 | -2.62 | -2.20 | -1.10 | -1.96 | -3.01 | -2.36 | -0.83 | -1.19 |
| JP-8, 10/09/03 | -0.24 | -0.47 | -3.97 | -2.29 | -2.62 | -2.23 | -1.07 | -1.96 | -3.13 | -2.37 | -0.87 | -1.18 |
| JP-8, 10/09/03 | -0.24 | -0.48 | -3.95 | -2.27 | -2.59 | -2.23 | -1.06 | -1.95 | -3.13 | -2.35 | -0.86 | -1.18 |
| *Configuration 3* | | | | | | | | | | | | |
| DF-2, 4/21/04 | 0.37 | -0.39 | -2.52 | -2.18 | -1.60 | -1.70 | -2.62 | -1.72 | -2.89 | | -0.98 | -3.41 |
| DF-2, 4/22/04 | 0.42 | -0.39 | -2.57 | -2.21 | -1.59 | -1.74 | -2.68 | -1.72 | -2.99 | | -0.97 | -3.48 |
| DF-2, 4/22/04 | 0.42 | -0.39 | -2.55 | -2.20 | -1.76 | -1.73 | -2.66 | -1.71 | -2.86 | | -0.97 | -3.44 |
| JP-8, 4/27/04 | 0.46 | -0.40 | -2.62 | -2.10 | -1.88 | -1.70 | -2.29 | -1.26 | -2.11 | 2.05 | -0.98 | -3.38 |
| JP-8, 4/28/04 | 0.41 | -0.47 | -2.63 | -2.11 | -1.97 | -1.70 | -2.30 | -1.27 | -2.14 | 1.20 | -1.01 | -3.43 |
| JP-8, 4/28/04 | 0.40 | -0.47 | -2.62 | -2.11 | -1.95 | -1.70 | -2.30 | -1.28 | -2.16 | 0.89 | -1.01 | -3.39 |

**Mixer Data, 4/16/2004**

| | AIR AFT IN TP6 | AIR AFT IN TP7 | AIR B4 FAN L/p1 | AIR B4 FAN L/p2 | AIR B4 FAN L/p3 | AIR B4 FAN L/p4 | AIR B4 FAN R/p1 | AIR B4 FAN R/p2 | AIR B4 FAN R/p3 | AIR B4 FAN R/p4 | AIR B4 FAN LTP1 | AIR B4 FAN LTP2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Configuration 3* | | | | | | | | | | | | |
| 0.33 | 0.09 | -1.03 | -4.75 | -4.32 | -6.18 | -2.97 | -4.94 | -3.70 | -5.68 | | -1.43 | -6.04 |
| 0.35 | 0.15 | -0.86 | -4.05 | -3.67 | -3.91 | -2.59 | -4.22 | -3.12 | -4.82 | | -1.26 | -5.10 |
| 0.37 | 0.26 | -0.59 | -2.90 | -2.61 | -2.09 | -1.97 | -3.01 | -2.17 | -3.42 | | -1.01 | -3.62 |

**Max Speed Test (w/DF-2 Fuel)**

| | AIR B4 FAN LTP3 | AIR B4 FAN LTP4 | AIR B4 FAN RTP1 | AIR B4 FAN RTP2 | AIR B4 FAN RTP3 | AIR B4 FAN RTP4 | DUCER RACK F | SURGE TANK PSI | Clnt>Rad 1 | Clnt>Rad 2 | ClntRad> 1 | ClntRad> 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| 12/30/2003 | -2.92 | -1.54 | -1.91 | -1.21 | -1.57 | -3.70 | 67.00 | 6.72 | 186.95 | 187.19 | 174.15 | 174.19 |
| 12/30/2003 | -2.95 | -1.55 | -1.95 | -1.23 | -1.59 | -3.73 | 66.64 | 6.68 | 184.06 | 184.30 | 171.66 | 171.78 |
| 12/30/2003 | -2.99 | -1.51 | -1.89 | -1.21 | -1.56 | -3.65 | 66.55 | 6.66 | 187.56 | 187.85 | 174.94 | 175.08 |
| ***Configuration 3*** | | | | | | | | | | | | |
| 4/26/2004 | -6.11 | -1.49 | -1.94 | -1.22 | -2.14 | -5.42 | 73.82 | 8.59 | 182.34 | 182.63 | 170.71 | 170.07 |
| 4/26/2004 | -5.38 | -1.47 | -1.89 | -1.21 | -2.09 | -5.28 | 74.10 | 8.75 | 180.40 | 180.31 | 169.11 | 168.36 |
| 4/26/2004 | -4.79 | -1.46 | -1.87 | -1.19 | -2.02 | -5.21 | 74.26 | 9.58 | 186.34 | 186.35 | 174.52 | 173.93 |
| 4/26/2004 | -4.66 | -1.23 | -1.33 | -2.36 | -4.61 | -2.74 | 74.45 | 10.46 | 190.20 | 188.81 | 179.05 | 178.23 |

**Fuel Consumption**

| | AIR B4 FAN LTP3 | AIR B4 FAN LTP4 | AIR B4 FAN RTP1 | AIR B4 FAN RTP2 | AIR B4 FAN RTP3 | AIR B4 FAN RTP4 | DUCER RACK F | SURGE TANK PSI | Clnt>Rad 1 | Clnt>Rad 2 | ClntRad> 1 | ClntRad> 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| DF-2, 10/15/03 | -1.23 | -0.81 | -0.91 | -0.55 | -0.84 | -1.71 | 77.39 | | 163.21 | 162.82 | 152.25 | 152.53 |
| DF-2, 10/15/03 | -1.24 | -0.82 | -0.92 | -0.56 | -0.84 | -1.71 | 76.53 | | 167.47 | 167.05 | 155.67 | 155.95 |
| JP-8, 10/09/03 | -1.28 | -0.78 | -0.89 | -0.54 | -0.85 | -1.76 | 75.90 | | 165.07 | 164.68 | 153.47 | 153.65 |
| JP-8, 10/09/03 | -1.27 | -0.78 | -0.88 | -0.53 | -0.84 | -1.74 | 75.46 | | 163.97 | 163.57 | 152.53 | 152.75 |
| ***Configuration 3*** | | | | | | | | | | | | |
| DF-2, 4/21/04 | -2.76 | -0.70 | -0.83 | -0.61 | -0.96 | -2.27 | 75.15 | 4.57 | 156.84 | 156.76 | 146.89 | 146.78 |
| DF-2, 4/22/04 | -2.61 | -0.71 | -0.90 | -0.60 | -0.96 | -2.28 | 75.49 | 4.87 | 161.83 | 161.62 | 151.25 | 151.13 |
| DF-2, 4/22/04 | -2.65 | -0.71 | -0.89 | -0.60 | -0.97 | -2.26 | 75.53 | 4.98 | 162.16 | 161.97 | 151.73 | 151.61 |
| JP-8, 4/27/04 | -2.05 | -0.68 | -0.86 | -0.66 | -1.09 | -1.88 | 74.54 | 7.95 | 164.83 | 165.76 | 154.25 | 154.25 |
| JP-8, 4/28/04 | -2.08 | -0.67 | -0.88 | -0.67 | -1.09 | -1.89 | 73.20 | 5.44 | 162.64 | 179.66 | 152.20 | 152.21 |
| JP-8, 4/28/04 | -2.08 | -0.68 | -0.86 | -0.67 | -1.09 | -1.88 | 74.19 | 5.75 | 164.76 | 166.19 | 154.30 | 154.36 |

**Mixer Data, 4/16/2004**

| | AIR B4 FAN LTP3 | AIR B4 FAN LTP4 | AIR B4 FAN RTP1 | AIR B4 FAN RTP2 | AIR B4 FAN RTP3 | AIR B4 FAN RTP4 | DUCER RACK F | SURGE TANK PSI | Clnt>Rad 1 | Clnt>Rad 2 | ClntRad> 1 | ClntRad> 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 3*** | | | | | | | | | | | | |
| 0.33 | -4.84 | -1.26 | -1.42 | -0.95 | -1.66 | -4.29 | 90.61 | 13.94 | 224.11 | 223.76 | 210.29 | 210.40 |
| 0.35 | -4.07 | -1.11 | -1.21 | -0.90 | -1.46 | -3.70 | 90.74 | 13.18 | 222.51 | 222.17 | 208.59 | 208.73 |
| 0.37 | -2.86 | -0.85 | -0.85 | -0.75 | -1.15 | -2.68 | 90.84 | 12.06 | 219.14 | 218.28 | 204.94 | 205.12 |

**Max Speed Test (w/DF-2 Fuel)**

| | Air>Rad 3 H2O | Air>Rad 4 H2O | Air>Rad 5 H2O | Air>Rad 6 H2O | Air>Rad 7 H2O | Air>Rad 8 H2O | Air>Rad 9 H2O | Air>Rad 10 H2O | AirRad> 1 H2O | AirRad> 2 H2O | AirRad> 3 H2O | AirRad> 4 H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| 12/30/2003 | 8.79 | 9.05 | 9.16 | 9.20 | 8.37 | 7.97 | 6.79 | 7.28 | 0.34 | 2.05 | 0.80 | 1.62 |
| 12/30/2003 | 8.89 | 9.13 | 9.26 | 9.24 | 8.45 | 8.07 | 6.85 | 7.35 | 0.35 | 2.08 | 0.82 | 1.65 |
| 12/30/2003 | 8.70 | 8.95 | 9.07 | 9.08 | 8.27 | 7.91 | 6.71 | 7.21 | 0.34 | 2.03 | 0.80 | 1.60 |
| ***Configuration 3*** | | | | | | | | | | | | |
| 4/26/2004 | 9.18 | 8.80 | 9.28 | 9.01 | 8.82 | 8.21 | 7.25 | 7.77 | 0.85 | 2.17 | 1.54 | 1.54 |
| 4/26/2004 | 8.98 | 8.57 | 9.09 | 8.80 | 8.63 | 8.03 | 7.08 | 7.61 | 0.83 | 2.11 | 1.50 | 1.50 |
| 4/26/2004 | 8.90 | 8.50 | 9.02 | 8.69 | 8.55 | 7.98 | 7.04 | 7.56 | 0.82 | 2.10 | 1.48 | 1.48 |
| 4/26/2004 | 8.16 | 8.20 | 6.87 | 5.75 | 4.96 | 5.41 | 4.84 | 4.93 | 0.41 | 1.56 | 0.94 | 1.02 |

**Fuel Consumption**

| | Air>Rad 3 H2O | Air>Rad 4 H2O | Air>Rad 5 H2O | Air>Rad 6 H2O | Air>Rad 7 H2O | Air>Rad 8 H2O | Air>Rad 9 H2O | Air>Rad 10 H2O | AirRad> 1 H2O | AirRad> 2 H2O | AirRad> 3 H2O | AirRad> 4 H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| DF-2, 10/15/03 | 3.85 | 4.03 | 3.99 | 4.18 | 3.66 | 3.51 | 2.99 | 3.18 | 0.13 | 0.70 | 0.53 | 0.53 |
| DF-2, 10/15/03 | 3.86 | 4.05 | 4.03 | 4.20 | 3.68 | 3.53 | 3.03 | 3.20 | 0.13 | 0.71 | 0.53 | 0.53 |
| JP-8, 10/09/03 | 3.89 | 4.06 | 4.08 | 4.23 | 3.68 | 3.54 | 3.01 | 3.19 | 0.15 | 0.73 | 0.53 | 0.54 |
| JP-8, 10/09/03 | 3.86 | 4.02 | 4.02 | 4.18 | 3.65 | 3.51 | 2.98 | 3.16 | 0.14 | 0.73 | 0.54 | 0.53 |
| ***Configuration 3*** | | | | | | | | | | | | |
| DF-2, 4/21/04 | 3.74 | 3.50 | 3.83 | 3.69 | 3.57 | 3.38 | 3.02 | 3.15 | 0.23 | 0.72 | 0.46 | 0.46 |
| DF-2, 4/22/04 | 3.78 | 3.55 | 3.88 | 3.78 | 3.64 | 3.43 | 3.07 | 3.20 | 0.22 | 0.75 | 0.46 | 0.48 |
| DF-2, 4/22/04 | 3.78 | 3.54 | 3.87 | 3.76 | 3.62 | 3.42 | 3.06 | 3.18 | 0.21 | 0.73 | 0.46 | 0.47 |
| JP-8, 4/27/04 | 3.71 | 3.52 | 3.41 | 3.34 | 3.26 | 3.22 | 2.95 | 3.03 | 0.21 | 0.71 | 0.42 | 0.46 |
| JP-8, 4/28/04 | 3.72 | 3.54 | 3.45 | 3.35 | 3.25 | 3.23 | 2.96 | 3.03 | 0.21 | 0.71 | 0.42 | 0.46 |
| JP-8, 4/28/04 | 3.71 | 3.54 | 3.45 | 3.35 | 3.25 | 3.23 | 2.96 | 3.03 | 0.20 | 0.69 | 0.42 | 0.45 |

**Mixer Data, 4/16/2004**

| | Air>Rad 3 H2O | Air>Rad 4 H2O | Air>Rad 5 H2O | Air>Rad 6 H2O | Air>Rad 7 H2O | Air>Rad 8 H2O | Air>Rad 9 H2O | Air>Rad 10 H2O | AirRad> 1 H2O | AirRad> 2 H2O | AirRad> 3 H2O | AirRad> 4 H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 3*** | | | | | | | | | | | | |
| 0.33 | 7.09 | 6.92 | 7.28 | 7.15 | 7.01 | 6.61 | 5.72 | 6.22 | 0.62 | 1.58 | 1.17 | 1.09 |
| 0.35 | 6.05 | 5.90 | 6.24 | 6.09 | 5.99 | 5.66 | 4.91 | 5.32 | 0.50 | 1.28 | 0.97 | 0.87 |
| 0.37 | 4.32 | 4.23 | 4.47 | 4.32 | 4.24 | 4.09 | 3.54 | 3.81 | 0.26 | 0.80 | 0.62 | 0.53 |

**Max Speed Test (w/DF-2 Fuel)**

| | Air>Rad 3 H2O | Air>Rad 4 H2O | Air>Rad 5 H2O | Air>Rad 6 H2O | Air>Rad 7 H2O | Air>Rad 8 H2O | Air>Rad 9 H2O | Air>Rad 10 H2O | AirRad> 1 H2O | AirRad> 2 H2O | AirRad> 3 H2O | AirRad> 4 H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| 12/30/2003 | 8.79 | 9.05 | 9.16 | 9.20 | 8.37 | 7.97 | 6.79 | 7.28 | 0.34 | 2.05 | 0.80 | 1.62 |
| 12/30/2003 | 8.89 | 9.13 | 9.26 | 9.24 | 8.45 | 8.07 | 6.85 | 7.35 | 0.35 | 2.08 | 0.82 | 1.65 |
| 12/30/2003 | 8.70 | 8.95 | 9.07 | 9.08 | 8.27 | 7.91 | 6.71 | 7.21 | 0.34 | 2.03 | 0.80 | 1.60 |
| ***Configuration 3*** | | | | | | | | | | | | |
| 4/26/2004 | 9.18 | 8.80 | 9.28 | 9.01 | 8.82 | 8.21 | 7.25 | 7.77 | 0.85 | 2.17 | 1.54 | 1.54 |
| 4/26/2004 | 8.98 | 8.57 | 9.09 | 8.80 | 8.63 | 8.03 | 7.08 | 7.61 | 0.83 | 2.11 | 1.50 | 1.50 |
| 4/26/2004 | 8.90 | 8.50 | 9.02 | 8.69 | 8.55 | 7.98 | 7.04 | 7.56 | 0.82 | 2.10 | 1.48 | 1.48 |
| 4/26/2004 | 8.16 | 8.20 | 6.87 | 5.75 | 4.96 | 5.41 | 4.84 | 4.93 | 0.41 | 1.56 | 0.94 | 1.02 |

**Fuel Consumption**

| | Air>Rad 3 H2O | Air>Rad 4 H2O | Air>Rad 5 H2O | Air>Rad 6 H2O | Air>Rad 7 H2O | Air>Rad 8 H2O | Air>Rad 9 H2O | Air>Rad 10 H2O | AirRad> 1 H2O | AirRad> 2 H2O | AirRad> 3 H2O | AirRad> 4 H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| DF-2, 10/15/03 | 3.85 | 4.03 | 3.99 | 4.18 | 3.66 | 3.51 | 2.99 | 3.18 | 0.13 | 0.70 | 0.53 | 0.53 |
| DF-2, 10/15/03 | 3.86 | 4.05 | 4.03 | 4.20 | 3.68 | 3.53 | 3.03 | 3.20 | 0.13 | 0.71 | 0.53 | 0.53 |
| JP-8, 10/09/03 | 3.89 | 4.06 | 4.08 | 4.23 | 3.68 | 3.54 | 3.01 | 3.19 | 0.15 | 0.73 | 0.53 | 0.54 |
| JP-8, 10/09/03 | 3.86 | 4.02 | 4.02 | 4.18 | 3.65 | 3.51 | 2.98 | 3.16 | 0.14 | 0.73 | 0.54 | 0.53 |
| ***Configuration 3*** | | | | | | | | | | | | |
| DF-2, 4/21/04 | 3.74 | 3.50 | 3.83 | 3.69 | 3.57 | 3.38 | 3.02 | 3.15 | 0.23 | 0.72 | 0.46 | 0.46 |
| DF-2, 4/22/04 | 3.78 | 3.55 | 3.88 | 3.78 | 3.64 | 3.43 | 3.07 | 3.20 | 0.22 | 0.75 | 0.46 | 0.48 |
| DF-2, 4/22/04 | 3.78 | 3.54 | 3.87 | 3.76 | 3.62 | 3.42 | 3.06 | 3.18 | 0.21 | 0.73 | 0.46 | 0.47 |
| JP-8, 4/27/04 | 3.71 | 3.52 | 3.41 | 3.34 | 3.26 | 3.22 | 2.95 | 3.03 | 0.21 | 0.71 | 0.42 | 0.46 |
| JP-8, 4/28/04 | 3.72 | 3.54 | 3.45 | 3.35 | 3.25 | 3.23 | 2.96 | 3.03 | 0.21 | 0.71 | 0.42 | 0.46 |
| JP-8, 4/28/04 | 3.71 | 3.54 | 3.45 | 3.35 | 3.25 | 3.23 | 2.96 | 3.03 | 0.20 | 0.69 | 0.42 | 0.45 |

**Mixer Data, 4/16/2004**

| | Air>Rad 3 H2O | Air>Rad 4 H2O | Air>Rad 5 H2O | Air>Rad 6 H2O | Air>Rad 7 H2O | Air>Rad 8 H2O | Air>Rad 9 H2O | Air>Rad 10 H2O | AirRad> 1 H2O | AirRad> 2 H2O | AirRad> 3 H2O | AirRad> 4 H2O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 3*** | | | | | | | | | | | | |
| 0.33 | 7.09 | 6.92 | 7.28 | 7.15 | 7.01 | 6.61 | 5.72 | 6.22 | 0.62 | 1.58 | 1.17 | 1.09 |
| 0.35 | 6.05 | 5.90 | 6.24 | 6.09 | 5.99 | 5.66 | 4.91 | 5.32 | 0.50 | 1.28 | 0.97 | 0.87 |
| 0.37 | 4.32 | 4.23 | 4.47 | 4.32 | 4.24 | 4.09 | 3.54 | 3.81 | 0.26 | 0.60 | 0.62 | 0.53 |

**Max Speed Test (w/DF-2 Fuel)**

| | AirRad> TP7 H2O | AirRad> TP8 H2O | AirRad> TP9 H2O | AirRad> TP10 H2O | Air>Exh Grl 1 | Air>Exh Grl 2 | Air>Exh Grl 3 | Air>Exh Grl 4 | Air>Exh Grl 5 | Air>Exh Grl 6 | Air>Exh Grl TP1 | Air>Exh Grl TP2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| 12/30/2003 | 6.58 | 2.68 | 2.26 | 4.22 | 0.33 | 1.63 | 1.16 | 1.50 | 0.90 | 1.27 | 2.97 | 3.04 |
| 12/30/2003 | 6.68 | 2.71 | 2.29 | 4.27 | 0.33 | 1.65 | 1.18 | 1.52 | 0.92 | 1.29 | 3.01 | 3.08 |
| 12/30/2003 | 6.51 | 2.64 | 2.24 | 4.17 | 0.32 | 1.60 | 1.14 | 1.47 | 0.89 | 1.25 | 2.94 | 3.01 |
| ***Configuration 3*** | | | | | | | | | | | | |
| 4/26/2004 | 5.04 | 2.83 | 1.99 | 4.35 | 0.06 | 1.68 | 1.20 | 1.70 | 0.97 | 1.37 | 2.47 | 3.36 |
| 4/26/2004 | 4.91 | 2.74 | 1.92 | 4.25 | 0.04 | 1.63 | 1.15 | 1.64 | 0.91 | 1.30 | 2.33 | 3.25 |
| 4/26/2004 | 4.85 | 2.72 | 1.90 | 4.21 | 0.03 | 1.62 | 1.16 | 1.63 | 0.91 | 1.30 | 2.35 | 3.25 |
| 4/26/2004 | 3.39 | 1.81 | 1.25 | 3.02 | -0.14 | 1.18 | 0.83 | 1.09 | 0.57 | 0.79 | 1.58 | 2.75 |

**Fuel Consumption**

| | AirRad> TP7 H2O | AirRad> TP8 H2O | AirRad> TP9 H2O | AirRad> TP10 H2O | Air>Exh Grl 1 | Air>Exh Grl 2 | Air>Exh Grl 3 | Air>Exh Grl 4 | Air>Exh Grl 5 | Air>Exh Grl 6 | Air>Exh Grl TP1 | Air>Exh Grl TP2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| DF-2, 10/15/03 | 2.23 | 0.90 | 0.67 | 1.83 | -0.15 | 0.40 | 0.22 | 0.33 | 0.13 | 0.21 | 0.30 | 0.59 |
| DF-2, 10/15/03 | 2.24 | 0.91 | 0.68 | 1.85 | -0.14 | 0.41 | 0.22 | 0.32 | 0.13 | 0.21 | 0.30 | 0.59 |
| JP-8, 10/09/03 | 2.24 | 0.94 | 0.67 | 1.84 | -0.12 | 0.46 | 0.27 | 0.35 | 0.14 | 0.26 | 0.31 | 0.63 |
| JP-8, 10/09/03 | 2.21 | 0.92 | 0.66 | 1.81 | -0.12 | 0.45 | 0.27 | 0.34 | 0.14 | 0.26 | 0.31 | 0.63 |
| ***Configuration 3*** | | | | | | | | | | | | |
| DF-2, 4/21/04 | 1.72 | 0.86 | 0.45 | 1.49 | -0.25 | 0.46 | 0.26 | 0.38 | 0.12 | 0.25 | 0.76 | 1.12 |
| DF-2, 4/22/04 | 1.74 | 0.86 | 0.49 | 1.50 | -0.26 | 0.45 | 0.25 | 0.37 | 0.11 | 0.24 | 0.77 | 1.14 |
| DF-2, 4/22/04 | 1.73 | 0.85 | 0.48 | 1.50 | -0.25 | 0.45 | 0.25 | 0.36 | 0.11 | 0.23 | 0.75 | 1.13 |
| JP-8, 4/27/04 | 1.59 | 0.79 | 0.44 | 1.44 | -0.25 | 0.39 | 0.21 | 0.33 | 0.11 | 0.18 | 0.75 | 1.12 |
| JP-8, 4/28/04 | 1.60 | 0.80 | 0.45 | 1.41 | -0.24 | 0.39 | 0.19 | 0.32 | 0.11 | 0.18 | 0.71 | 1.09 |
| JP-8, 4/28/04 | 1.60 | 0.80 | 0.44 | 1.44 | -0.24 | 0.39 | 0.20 | 0.33 | 0.11 | 0.18 | 0.72 | 1.11 |

**Mixer Data, 4/16/2004**

| | AirRad> TP7 H2O | AirRad> TP8 H2O | AirRad> TP9 H2O | AirRad> TP10 H2O | Air>Exh Grl 1 | Air>Exh Grl 2 | Air>Exh Grl 3 | Air>Exh Grl 4 | Air>Exh Grl 5 | Air>Exh Grl 6 | Air>Exh Grl TP1 | Air>Exh Grl TP2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 3*** | | | | | | | | | | | | |
| 0.33 | 3.67 | 2.13 | 1.32 | 3.37 | -0.12 | 1.14 | 0.78 | 1.22 | 0.62 | 0.91 | 1.84 | 2.51 |
| 0.35 | 3.04 | 1.74 | 1.01 | 2.84 | -0.18 | 0.90 | 0.60 | 0.95 | 0.46 | 0.69 | 1.49 | 2.06 |
| 0.37 | 2.00 | 1.10 | 0.53 | 1.89 | -0.28 | 0.51 | 0.31 | 0.53 | 0.20 | 0.33 | 0.93 | 1.35 |

**Max Speed Test (w/DF-2 Fuel)**

| | AirRad> TP7 H2O | AirRad> TP8 H2O | AirRad> TP9 H2O | AirRad> TP10 H2O | Air>Exh Grl 1 | Air>Exh Grl 2 | Air>Exh Grl 3 | Air>Exh Grl 4 | Air>Exh Grl 5 | Air>Exh Grl 6 | Air>Exh Grl TP1 | Air>Exh Grl TP2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| 12/30/2003 | 6.58 | 2.68 | 2.26 | 4.22 | 0.33 | 1.63 | 1.16 | 1.50 | 0.90 | 1.27 | 2.97 | 3.04 |
| 12/30/2003 | 6.68 | 2.71 | 2.29 | 4.27 | 0.33 | 1.65 | 1.18 | 1.52 | 0.92 | 1.29 | 3.01 | 3.08 |
| 12/30/2003 | 6.51 | 2.64 | 2.24 | 4.17 | 0.32 | 1.60 | 1.14 | 1.47 | 0.89 | 1.25 | 2.94 | 3.01 |
| ***Configuration 3*** | | | | | | | | | | | | |
| 4/26/2004 | 5.04 | 2.83 | 1.99 | 4.35 | 0.06 | 1.68 | 1.20 | 1.70 | 0.97 | 1.37 | 2.47 | 3.36 |
| 4/26/2004 | 4.91 | 2.74 | 1.92 | 4.25 | 0.04 | 1.63 | 1.15 | 1.64 | 0.91 | 1.30 | 2.33 | 3.25 |
| 4/26/2004 | 4.85 | 2.72 | 1.90 | 4.21 | 0.03 | 1.62 | 1.16 | 1.63 | 0.91 | 1.30 | 2.35 | 3.25 |
| 4/26/2004 | 3.39 | 1.81 | 1.25 | 3.02 | -0.14 | 1.18 | 0.83 | 1.09 | 0.57 | 0.79 | 1.58 | 2.75 |

**Fuel Consumption**

| | AirRad> TP7 H2O | AirRad> TP8 H2O | AirRad> TP9 H2O | AirRad> TP10 H2O | Air>Exh Grl 1 | Air>Exh Grl 2 | Air>Exh Grl 3 | Air>Exh Grl 4 | Air>Exh Grl 5 | Air>Exh Grl 6 | Air>Exh Grl TP1 | Air>Exh Grl TP2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 1*** | | | | | | | | | | | | |
| DF-2, 10/15/03 | 2.23 | 0.90 | 0.67 | 1.83 | -0.15 | 0.40 | 0.22 | 0.33 | 0.13 | 0.21 | 0.30 | 0.59 |
| DF-2, 10/15/03 | 2.24 | 0.91 | 0.68 | 1.85 | -0.14 | 0.41 | 0.22 | 0.32 | 0.13 | 0.21 | 0.30 | 0.59 |
| JP-8, 10/09/03 | 2.24 | 0.94 | 0.67 | 1.84 | -0.12 | 0.46 | 0.27 | 0.35 | 0.14 | 0.26 | 0.31 | 0.63 |
| JP-8, 10/09/03 | 2.21 | 0.92 | 0.66 | 1.81 | -0.12 | 0.45 | 0.27 | 0.34 | 0.14 | 0.26 | 0.31 | 0.63 |
| ***Configuration 3*** | | | | | | | | | | | | |
| DF-2, 4/21/04 | 1.72 | 0.86 | 0.45 | 1.49 | -0.25 | 0.46 | 0.26 | 0.38 | 0.12 | 0.25 | 0.76 | 1.12 |
| DF-2, 4/22/04 | 1.74 | 0.86 | 0.49 | 1.50 | -0.26 | 0.45 | 0.25 | 0.37 | 0.11 | 0.24 | 0.77 | 1.14 |
| DF-2, 4/22/04 | 1.73 | 0.85 | 0.48 | 1.50 | -0.25 | 0.45 | 0.25 | 0.36 | 0.11 | 0.23 | 0.75 | 1.13 |
| JP-8, 4/27/04 | 1.59 | 0.79 | 0.44 | 1.44 | -0.25 | 0.39 | 0.21 | 0.33 | 0.11 | 0.18 | 0.75 | 1.12 |
| JP-8, 4/28/04 | 1.60 | 0.80 | 0.45 | 1.41 | -0.24 | 0.39 | 0.19 | 0.32 | 0.11 | 0.18 | 0.71 | 1.09 |
| JP-8, 4/28/04 | 1.60 | 0.80 | 0.44 | 1.44 | -0.24 | 0.39 | 0.20 | 0.33 | 0.11 | 0.18 | 0.72 | 1.11 |

**Mixer Data, 4/16/2004**

| | AirRad> TP7 H2O | AirRad> TP8 H2O | AirRad> TP9 H2O | AirRad> TP10 H2O | Air>Exh Grl 1 | Air>Exh Grl 2 | Air>Exh Grl 3 | Air>Exh Grl 4 | Air>Exh Grl 5 | Air>Exh Grl 6 | Air>Exh Grl TP1 | Air>Exh Grl TP2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Configuration 3*** | | | | | | | | | | | | |
| 0.33 | 3.67 | 2.13 | 1.32 | 3.37 | -0.12 | 1.14 | 0.78 | 1.22 | 0.62 | 0.91 | 1.84 | 2.51 |
| 0.35 | 3.04 | 1.74 | 1.01 | 2.84 | -0.18 | 0.90 | 0.60 | 0.95 | 0.46 | 0.69 | 1.49 | 2.06 |
| 0.37 | 2.00 | 1.10 | 0.53 | 1.89 | -0.28 | 0.51 | 0.31 | 0.53 | 0.20 | 0.33 | 0.93 | 1.35 |

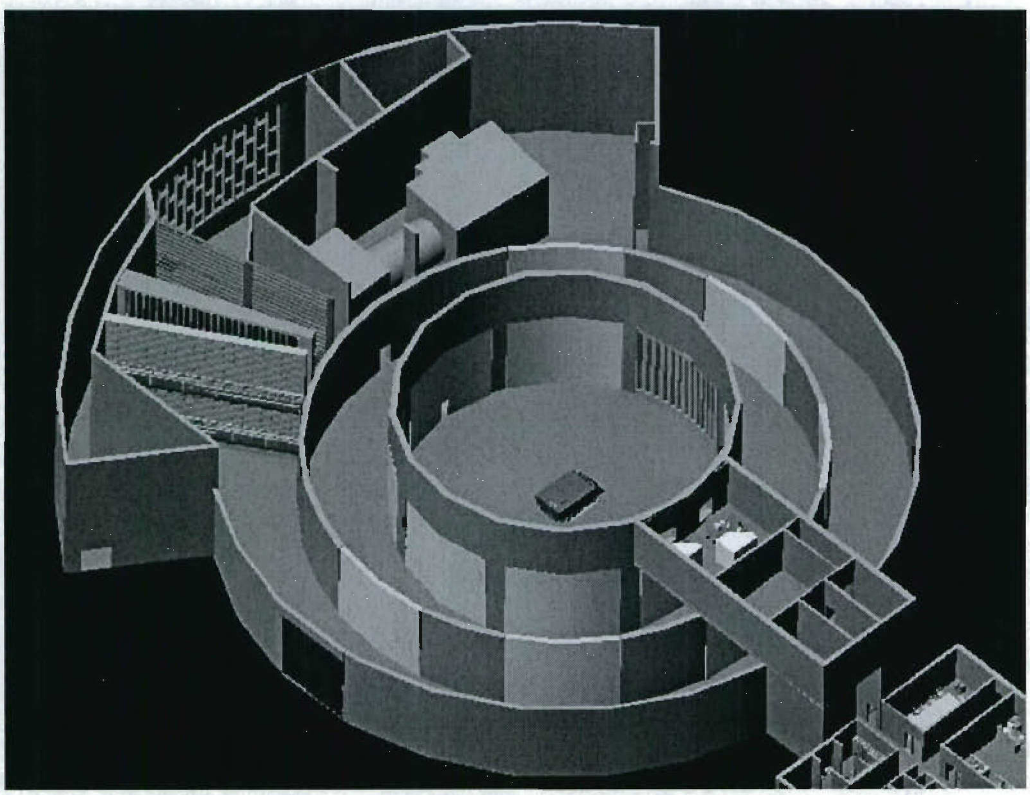
# APPENDIX C

*TEST PLAN*

# M109A6 Paladin Self Propelled Howitzer Full Load High Ambient Cooling Test

TEST PLAN

July 10, 2003



## 0.0 Objective

The objective of this test is to conduct a full load high ambient cooling test on an M109A6 Paladin with an up-powered engine to obtain data with respect to:

- Up-powered engine performance
- Vehicle cooling capability
- Options to improve vehicle cooling (as required)

## 1.0 Outline of Work to be Performed

a. Instrument Baseline vehicle/powerpack
b. Conduct full load heating and cooling test
c. Remove and upgrade powerpack with new engine and torque converter
d. Re-instrument vehicle/powerpack as necessary
e. Conduct full load heating and cooling test on modified configuration

## 2.0 Test Equipment

Test Cell #9 in building 212 at TARDEC will be used to conduct the tests (see picture on cover page). Cell #9 is a large atmospheric test chamber capable of inducing a number of wind and temperature points. Cell temperatures can be controlled to range from ambient up to 160°F. Simulation of solar radiation is possible. Wind speed of up to 20 mph can be achieved from any of eight different directions. The cell contains two absorption dynamometers capable of absorbing 88,000 ft-lbs of torque per vehicle side at speeds from 15 – 2500 rpm. The dynamometers can absorb 128,000 ft-lbs of torque at stall.

## 3.0 Test Material

a. M109A6 Paladin Self Propelled Howitzer, Army S/N 12A30966, Manufacture Date 7/92
b. Modified Engine: DDC 8V71T Low Heat Rejection Diesel Engine – S/N 08VA458207F, 500 BHP @ 2300 RPM
c. Base Engine: DDC 8V71T Low Heat Rejection Diesel Engine – S/N 08VA452020, 440 BHP @ 2300 RPM
d. Transmission: Allison XTG411-4, S/N 4294, 4 forward speeds, 2 reverse speeds
e. Modified Torque Converter: Allison model TC396, P/N AT120375 S/N 1
f. Stock Torque Converter: Allison model TC360, S/N xxxxx
g. Radiator: Young Radiator Company, P/N 318399 S/N 2669107
h. Fan: Moda Magnetics Corp Vane Axial Fan, P/N 12268231, S/N 0018

## 4.0 Vehicle Background

The vehicle being tested is an M109A6 Paladin Self Propelled Howitzer. In addition to the baseline configuration, a modified and upgraded version will also be tested. This version differs from a production version in that it incorporates a new up-powered Detroit Diesel 8V71T engine. This new engine is expected to generate 500 uninstalled horsepower. The XTG-411 transmission has also been updated with the incorporation of a new input torque converter, an Allison TC396.

## 5.0 Engineering Tests

The following tests will be performed on the vehicle:

a) The Prime Power Unit will be evaluated for full-load cooling performance. This test will be performed using only JP-8 fuel. Test configurations will include a baseline model Paladin and the same vehicle incorporating the modified/upgraded DDC engine and Allison torque converter.

## 6.0 Miscellaneous Vehicle Preparation

### 6.1 Cooling System

Engine and Transmission Oil Coolers:

The oil coolers must be free of debris or any evidence of plugging. The radiator fins must be straight and clear. There must be no evidence of oil leakage. Any suspect cooler will be pressurized and checked prior to testing.

### 6.2 Cooling Fan Drive

a. The engine and cooling fan must be operational for checkout of the fan drive
b. Engine compartment must be fully closed and the fan controller valve in the override position

### 6.3 Air Intake System

Install new air cleaner element for the engine. Inspect the air cleaner assembly for cracks, torn hoses, and improper installation. Repair as necessary. Check for kinked hoses especially on scavenge line.

### 6.4 Filtration Systems

a. Install new oil filter and oil for engine and transmission
b. Install new fuel filters in the engine

### 6.5 Thermostats

Thermostats must be blocked open for the test

### 6.6 Engine Compartment

a. Inspect compartment access panels for proper sealing.
b. Check all possible compartment leakage paths. Inspect radiator inlet plenum for proper sealing around the radiator, such that no inlet air will bypass the radiator.

## 7.0 Special Test Vehicle Preparation

A stock vehicle will be delivered to TARDEC building 212. It will be tested in its stock configuration to set a baseline for comparison purposes. Then the stock powerpack will be removed from the vehicle to undergo some modifications. Army technicians will remove the stock TC360 torque converter and replace it with the PM Paladin/FAASV supplied Allison TC396 torque converter.

A PM Paladin/FAASV supplied 500 HP 8V71T engine will be substituted for the stock diesel engine. The powerpack will then be reassembled.

## 8.0 Instrumentation

The Paladin vehicle and powerpack will be instrumented per the list in Appendix A.

## 9.0 Pre-test Equipment Check Out

9.1 Technical Inspection – Preventative Maintenance Checks and Services (TI-PMCS)

9.1.1 Conduct vehicle TI-PMCS per technical manual

9.1.2 Note any discrepancies but do not repair without consultation with Engineering staff and Program Manager's office.

9.2 Unit Floor Check

A unit floor check is required so that instrumentation can be verified to be operating properly before the powerpack is reinstalled in the vehicle.

a. Disconnect and remove engine from vehicle. Connect the necessary instrumentation and wiring to ground hop the engine Calibrate all instrumentation to insure proper data readings.
b. Make sure that all fluids are at the normal operating levels.
c. Start engine.
d. Check that instrumentation is performing properly and for leaks.
e. Adjust and/or repair deficiencies, if any.
f. Shut-off engine. Reinstall powerpack into vehicle.

9.3 Engine in-vehicle Check

This check is to verify that the engine is operating normally in the vehicle prior to conducting the FLCT and to verify transmission output and location of 100% throttle points.

a. This test to be conducted at test cell ambient temperature of 70-80$^0$ F.
b. Start the engine and bring it up to operating temperature limits.
c. With the engine at normal operating temperature and pressure limits, and no applied load, make a complete instrument checkout. Apply part load to driveline and repeat instrument checkout.
d. Perform a one hour system check as follows: Transmission selector in forward, full throttle and engine speed of 2300 ± 20 and record dynamometer torque.
e. Following system check, record:
    1. Engine governed speed with no load applied
    2. Engine idle speed with no load applied
    3. Sprocket torque and speed at engine rated power at 100% throttle.

9.4 Vehicle Performance Check

This check will verify all systems and instrumentation are simultaneously operating properly in the vehicle prior to conducting FLCT.

Conduct full power performance check at the following conditions. (Do not exceed maximum temperature limits)

a. Transmission selector in forward
b. Engine at full throttle and power (Determined from engine in vehicle check, part 9.3)
c. Ambient Temp at $90^0$F ± $10^0$F
d. Fuel supplied at $150^0$F ± $3^0$F
e. Exhaust outlet pressure, atmospheric.
f. Test cell air flow velocity at 5 ±mph

**10.0 Vehicle Full Load Cooling Tests (FLCT)**

All full load cooling tests will be conducted at $115^0$ F ambient (per Paladin spec MIL-H-71000A).

a. The vehicle temperature is considered to be reached when vehicle fluid readings experience no temperature change beyond ± $1^0$F (except for those changes caused by minor ambient temperature changes) over a minimum of a 20 min. time period, or three temperature readings, separated by 10 min. intervals. For each test run, the Solar Radiation Simulator light bank shall be positioned over the engine compartment to provide for a solar radiation effect of 350 BTU/sq. ft/hr for test ambient $100^0$F and above. The cell must be presoaked at the required test temperature for a minimum for two hours prior to the start of testing. Bring up to within ± $1^0$F.

Note: Engine and transmission fluid levels should be checked daily and kept at operating levels during the testing sequences. Logs will be taken before running and after shutdown.

With:

- Full throttle Position.
- Exhaust outlet pressure, atmospheric
- Transmission selector in forward, gear 1.

Run I – Set torque on each side to 9,058 lb-ft or 0.35 TE/wt Ratio

Run II – Set torque on each side to 11,646 lb-ft or 0.45 TE/wt Ratio

Run III – Set torque on each side to 12,940 lb-ft or 0.50 TE/wt Ratio

Run IV – Set torque on each side to 13,198 lb-ft or 0.51 TE/wt Ratio

Run V – Increase TE/WT ratio by 0.01 and record the highest TE achievable, without exceeding critical operating temperatures and pressures. Cease incremental testing once critical temperatures are exceeded or when temperatures can no longer be stabilized.

Critical Temperatures

Engine oil sump temperature = 275°F

Oil to Transmission oil cooler inlet = 300°F

Maximum Coolant from Engine = 230°F

**NOTE:** TE/WT ratios are based upon a Paladin vehicle weight of 63,300 pounds.

**Warning**: Do not shut off engine under these conditions. If maximum limits should occur, finish test run and reduce torque and throttle to idle and allow engine to cool down before shutting off.

## 11.0 Additional Tests to Verify Conformance to M109 Specification

1. Fuel consumption
   The Paladin's has a fuel consumption requirement of achieving 186 miles while operating at 25 mph while operating on a primary road. The purpose of this test is to determine the Paladin's ability to comply with this requirement.

Bring test cell temperature to 77°F (if not possible consult engineering staff on how to proceed). Engage transmission in lockup gear 4. Bring engine to 1483 RPM. This is equivalent to the vehicle cruising speed of 25 mph (equivalent to a dynamometer speed of 428 RPM). Set absorption dynamometer load to 1156 ft-lbs per side (equivalent to a NATO Reference Mobility Model rolling resistance definition of primary road). Allow vehicle temperatures to stabilize. Operate vehicle under this condition for a 1-hour period while recording fuel consumption. Bring vehicle to idle. Repeat one time.

Data acquisition: Log data at one-minute intervals during the test.

*Assumptions for Fuel Consumption Calculations*:
Coefficient of Drag: 0.8
Density of Air: 0.075 $lb_M/ft^3$
Vehicle Frontal Area: 108 $ft^2$
Gross Vehicle Weight: 63,300 lbs
NRMM Rolling Resistance: 85 lb/ton
Percent Grade: 0%

1. Maximum Vehicle Speed
   The vehicle specification for the Paladin requires that the vehicle be able to achieve a top speed of 38 miles per hour on a hard level road. The purpose of this test is to determine the Paladin's top speed capability.

Bring test cell temperature to 77°F (if not possible consult engineering staff on how to proceed). Load absorption dynamometers per table 1. The values in this table simulate wind resistance and also incorporate the rolling resistance the vehicle would encounter on a primary road as defined in the NATO Reference Mobility Model (NRMM). Gradually increase vehicle speed until no more increase is possible. Attempt to maintain speed for 5 minutes. If not possible, attempt to maintain speed at 1 mph less. Record the maintainable speed as the vehicle's top speed. Reduce speed to idle. Repeat test 3 times. The three tests should yield top speed values within ±1 mph of each other for top speed result to be considered valid.

| Attempted Vehicle Speed (mph) | Dynamometer Torque Load (per side) (ft-lbs) | Dyno Absorption Speed (RPM) |
|---|---|---|
| 34 | 1202 | 582 |
| 35 | 1208 | 600 |
| 36 | 1215 | 617 |
| 37 | 1221 | 634 |
| 38 | 1228 | 651 |
| 39 | 1234 | 668 |
| 40 | 1241 | 685 |
| 41 | 1249 | 702 |
| 42 | 1256 | 719 |
| 43 | 1263 | 737 |
| 44 | 1271 | 754 |

Table 1 – Dyno Torque Load per Speed Attempted

Data acquisition: Log data in a consistent manner throughout the entire attempt to obtain a top speed.

Other Speed Test Assumptions:

Coefficient of Drag: 0.8
Density of Air: 0.075 $lb_M/ft^3$
Vehicle Frontal Area: 108 $ft^2$
Gross Vehicle Weight: 63,300 lbs
NRMM Rolling Resistance: 85 lb/ton
Percent Grade: 0%

## 12.0 Vehicle removal and Test Cell Teardown

Upon release of the vehicle by the test engineer:

1. Disconnect and remove all instrumentation from vehicle

Restore vehicle to original condition*

*NOTE: Modified engine and torque converter are to remain **installed** in the vehicle

Perform vehicle check out to insure proper functionality

## 13.0 Final Report

Upon completion of testing, a final report will be prepared, within 3 – 4 weeks, and forwarded to PM Paladin/FAASV (SFAE-GCS-CR-P).

## APPENDIX A – INSTRUMENTATION LIST

Engine

1. Install instrumentation to obtain and record the following data points, but not limited to:

| A. Immersion Type – Temperature ($^0$F) | Range | Accuracy |
|---|---|---|
| 1. Oil engine gallery | 70-275 max | ±1 |
| 2. Oil before sump | 70-275 max | ±1 |
| 3. Oil before engine oil cooler | 70-300 | ±1 |
| 4. Oil after engine oil cooler | 70-300 | ±1 |
| 5. Oil transmission sump | 70-350 | ±1 |
| 6. Oil before transmission oil cooler | 70-350 | ±1 |
| 7. Oil after transmission oil cooler | 70-350 | ±1 |
| 8. Coolant into radiator | 70-230 max | ±1 |
| 9. Coolant out of radiator | 70-250 | ±1 |
| 10. Coolant into transmission cooler | 70-250 | ±1 |
| 11. Coolant out of transmission cooler | 70-250 | ±1 |
| 12. Fuel supply | 70-150 | ±1 |
| 13. Fuel spillback | 70-150 | ±1 |
| 14. Coolant into engine oil cooler | 70-250 | ±1 |
| 15. Coolant out of engine oil cooler | 70-250 | ±1 |
| **B. Air Type – Temperatures** | | |
| 2. Air before radiator intake side | 70-250 | ±2 |
| 3. Air after radiator exhaust side | 70-250 | ±2 |
| 4. Air into fan intake - left | 70-250 | ±2 |
| 5. Air into fan intake – right | 70-250 | ±2 |
| 7. Air into turbo intake* | 70-250 | ±2 |
| 8. Compressor out air* | 70-200 | ±2 |
| 9. Air in test cell (ambient) | 70-115 max | ±2 |
| 10. Exhaust before turbine* | 350-1350 | ±2 |
| 11. Exhaust after turbine* | 300-1200 | ±2 |
| 12. Intake manifold* | 70-350 | ±2 |
| 16. Air before Inlet Grille | 70-150 | ±1 |
| 17. Air after Inlet Grille | 70-200 | ±1 |
| 18. Air before Exhaust Grille | 70-300 | ±1 |
| 19. Air after Exhaust Grille | 70-301 | ±1 |

* - Immersion type

### C. Pressures

| | | |
|---|---|---|
| 1. Air before radiator, in water | 0-25 | ±1 |
| 2. Air after radiator, in water | 0-25 | ±1 |
| 3. Air before fan, in water | 0-25 | ±1 |
| 5. Air cell ambient, in water | 0-5 | ±0.5 |
| 6. Air before air filter, in water | 0-50 | ±1 |
| 7. Air before turbo, in water | 0-50 | ±1 |
| 8. Coolant block pressure, psi | 0-30 | ±1 |
| 9. Coolant after radiator, psi | 0-30 | ±1 |
| 10. Coolant before radiator, psi | 0-30 | ±1 |
| 11. Coolant at surge tank, psi | 0-30 | ±1 |
| 12. Engine oil gallery, psi | 0-100 | ±1 |
| 13. Transmission make-up, psi | 0-200 | ±1 |
| 14. Exhaust before turbo, psig | 0-30 | ±1 |
| 15. Barometric pressure, in. Hg | 0-35 | ±0.5 |
| 16. Fuel supply, psi | 0-5 | ±1 |
| 17. Fuel rail, psi | 0-200 | ±1 |
| 18. Exhaust after turbo, psi | 0-4 | ±1 |
| 19. Intake manifold pressure, psi | | |
| 20. Fuel Spillback | | |
| 21. Air before Intake grille | 0-25 | ±1 |
| 22. Air after Intake grille | 0-25 | ±1 |
| 23. Air before Exhaust grille | 0-25 | ±1 |
| 24. Air after Exhaust grille | 0-25 | ±1 |

### D. Flows

| | | |
|---|---|---|
| 1. Air cleaner Scavenge Flow, cfm | TBD | TBD |
| 2. Coolant Flow, gpm | 50-250 | ±2 |
| 3. Transmission oil Flow | | |
| 4. Engine oil Flow | 20-60 gpm | |
| 5. Air Flow Before Fan, Left | | |
| 6. Air Flow Before Fan, Right | | |
| 8. Air after Intake grille | | |
| 10. Air Flow After Radiator, ft/s | | |
| 11. Air Flow Before Exhaust Grille | | |

### E. Additional Plotted Output

1. Oil Delta Temp. across engine oil cooler
2. Oil Delta Temp. across the transmission oil cooler

3. Coolant Delta Temp. across radiator
4. Coolant Delta Temp. across transmission cooler
5. Average air temp before radiator
6. Average air temp after radiator
7. Average cell ambient air temperature
8. Air rise delta temp across radiator
9. Extrapolation factor
10. Coolant delta pressure across radiator
11. Sprocket power (North and South)
12. Total sprocket power (North and South)
13. Engine to fan speed ratio
14. Calculated cooling air flow

Note: Highlight these channels

| **F. Additional Instrumentation** | Range | Accuracy |
|---|---|---|
| 1. Socket output torque at dynamometers | 0-25000 | ±20 lb-ft (North –South) |
| 2. Sprocket output speed at dynamometers | 0-1000 | ±0.1 RPM, (North – South) |
| 3. Engine Speed, RPM | 0-3000 | ±1 |
| 4. Fuel flow, lb/hr | 0-350 | ±1 |
| 5. Fan speed, RPM | 0-5500 | ±? |

| **G. Temperature and Pressure warning limits** | Warning | Max Limit |
|---|---|---|
| 1. Engine oil sump temperature, $^0$F | 260 | 275 |
| 2. Coolant into transmission cooler, $^0$F | 225 | 230 |
| 3. Transmission oil cooler inlet, $^0$F | 280 | 300 |
| 4. Maximum Coolant from Engine, °F | 215 | 230 |
| 5. Engine Oil Pressure, psi | 65 | 71 |
| | | Min Limit |
| 6. Engine oil pressure, psi | 35 | 30 |
| 7. Transmission make-up pressure, psi | 100 | 90 |

**H. Building Channels**

# APPENDIX D

*Engine Product Qualification Test Report*

*Detroit Diesel Corporation*

*DETROIT DIESEL CORPORATION*

**8V71T-LHR – 500 BHP**
**for**
**U.S. ARMY TACOM**
**M109A6 Paladin/M992 FAASV Upgrade**

**TACOM TESTS and EPQ October 2003 through April 2004**
**R.G.Hewlett - 09 July, 2004**

**Final Report Part - II**

**Part I** reports on the DDC Room 20 dynamometer test of the 500 BHP engine, April-May, 2003.

**Part II** Covers the U.S. Army TACOM vehicle dynamometer tests in the TARDEC building 212, test cell #9 environmental chamber and the DDC run EPQ.

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## Part II of II

**Purpose and Objective:**

To determine the effects of increasing the BHP from 440 to 500 for use in the M109A6 Howitzer (Paladin) and the M992A1 FAASV vehicles. Run full load cooling tests (FLCT) to determine the highest tractive effort capable without exceeding oil and coolant temperature limits. See discussion section for definition of tractive effort as applied here.

The chronological history of the 8V71T (7083-7391) engine for the M-109A Howitzer development and ratings from the original 405 BHP standard configuration in 1985 through the Low Heat Rejection (LHR) phase development to 440 BHP in 1987 was described in Part I of this report. Part I also describes additional attempts to reduce heat rejection and increase horsepower to 500 and above. The engine specification changes for this 500 BHP version are also reported in Part I.

Unit No. 8VA-458207F was one of two units built at the Detroit Diesel Corporation (DDC) remanufacturing center for this project. After pre-testing in production and then running the engine in the DDC E-04 test lab to establish the performance curve and heat rejection, the engine was sent to TACOM for testing in an M109 Paladin on a vehicle dynamometer in the TARDEC environmental chamber of test cell #9 in building 212. The environmental chamber is a large room with steam heating elements to control the environmental ambient condition. The vehicle drive tracks were removed and two dynamometers were hooked up, one to each of the right and left side front drive sprockets.(See photo No.4 in Appendix II).

Because of the torque rise characteristics of the engine, increasing as the RPM is lowered, the higher TE/Wt ratios were obtained at lower RPM's, up to the engine torque peak point at 1200 RPM. As testing progressed an exhaust leak began to obscure the results, so a new exhaust system was installed and the radiator cleaned.(See fig.7).

In addition to the TACOM test plan, DDC contributed time and effort to run Engine Product Qualification (EPQ) tests and complete the associated EPQ form. All of the EPQ no load testing was with the power pack out of the vehicle and then TACOM dynamometer data was used for the full load portions, such as cooling index, exhaust backpressure, and air inlet restriction.

### Results:

### A. Full Load Cooling Tests (FLCT ), (TACOM):

a) ***440 BHP engine/TC-360*** was able to reach 0.33 tractive effort /weight ratio in 115°F ambient and achieve stabilization without exceeding engine or transmission temperature limits.

b) ***440/TC-396*** combination reached 0.34 TE in 115°F.

c) ***500 HP/TC-396 engine*** was able to accomplish 0.37 TE/Wt at 115°F. The engine coolant temperature was 227°F and the oil sump temperature was running at 280 - 285°F and the transmission oil was 239°F. Up to 0.6 TE was accomplished at other ambient conditions.

### B. EPQ (DDC):

a) The ***system fill, drawdown, and deaeration*** all were quite adequate to consider them as passable for DDC specs. See discussion for details.

b) The ***cooling index*** is such as to permit operation under TACOM test specifications in 115°F ambient, but under the test conditions the oil sump temperatures exceeded DDC suggested limit of 250°F and TACOM spec of 275°F. A limit of 290°F for test purposes was allowed by DDC after consulting with the oil supplier.

c) The ***exhaust back pressure and air inlet restrictions*** exceed DDC suggested limits in both the baseline and the upgraded version.

## Conclusions:

1. The application of the 500 BHP engine at 0.37 TE appears to be successful for performance goals and allowable test limits for engine coolant and transmission oil temperatures. However engine **oil sump temperatures were running high** in the 115°F ambient tests. These limits do not necessarily reflect actual field operating conditions. Field testing would have to be done to determine this.

2. All tests were run with plain water and a rust inhibitor. The **usage of 50/50 anti-freeze** is expected to cause a 4-6°F warmer running engine temperature under the same full load test conditions. In desert or tropical environments, it is more likely that antifreeze would not be used anyway.

3. A **high temperature rise in the engine compartment** (30°F and more) contributes to early temperature limits being encountered. Restricted airflow through the ballistic grills is a partial contributor to this.

## Recommendations:

1. If additional **FLCT** developmental testing of the 8V71T is needed and if better cooling for the required TE is desired.
    a) Test using the **8V92 coolant pump**.
    b) Test using **part load** at lower RPM's thus less horsepower and heat rejection. This done either by lowering the injector calibrations, or backing off of the throttle at lower RPM's (R.Hewlett plan).
    c) Apply **pre-cooling** of the compressed intake air.
    d) Run a set of tests using **50/50 anti-freeze** or what is normally used in actual field conditions.
    e) Test with the **ballistic grills** open to determine the % contribution of restricted airflow for cooling and see if a lesser resistant grill can be designed.
2. Determine where the exhaust backpressure and air inlet restrictions can be reduced to accommodate the higher horsepower package.
3. Should the engine be considered for release to production, Proving Ground tests and a NATO test should be a part of it.

## Discussion:

The TACOM objective was to run full load cooling tests ***(FLCT)*** at high ambient (115°F) and achieve maximum tractive effort without exceeding the following specified limits listed below:

- Engine Coolant Out Temp. =230°F
- Engine Sump Temperature =275°F *
- Transmission Oil to Cooler Temperature =300°F

** The sump temperature limit for <u>these tests only</u> was increased to 290°F with DDC approval after contacting the oil supplier direct by DDC Met-Lab personnel. The oil, Exxon-Mobil Delvac-1300-15-W-40 was OK'd by the supplier to go as high as 330°F, which is equivalent to their lab test temperatures.*

The tractive effort (TE) is the pulling power of the vehicle for a given weight without track slippage. It is a result of the engine torque multiplied by the various gear and axle reductions and the track drive dimensions. The tests were based on the maximum tractive effort for a 63,300 lb vehicle or TE/Wt. The test data used TE to mean the same thing. Ratios of 0.3 through 0.6 were run.

The test plan called for baseline testing leading to 4 configurations to test:

1. Present configuration 440 BHP Engine with TC-360 Torque Converter
2. 440 BHP engine with TC-396 torque converter
3. 500 BHP engine with TC-360 torque converter
4. 500 BHP Engine with TC-396 torque converter

Only configurations 1,2, and 4 were actually run.

## I. TACOM FLCT Test Results (Fig.1)

**Fig. 1** Table of overall results at 115°F ambient:

| Configuration (BHP/Torque Converter) | 440BHP/TC-360 | 440BHP/TC-396 | 500BHP/TC-360 | 500BHP/TC-396 |
|---|---|---|---|---|
| Highest TE/Wt in 115°F ambient | 0.33 | 0.34 | N/A | 0.37 |
| Total sprocket torque Ft.Lbs | 1699 | 1768 | N/A | 1916 |
| Engine RPM | 1631 | 1651 | N/A | 1610 |
| Coolant Out Temp °F | 221.4 | 220.4 | N/A | 227.3 |
| Engine Oil Sump Temp °F | 260.6 | 260.7 | N/A | 280.3 |
| Transmission Oil to Cooler °F | 235 | 234.1 | N/A | 239 |
| Data file date/time/no. | 121003/14:42/-- | 020504/14:30/-- | N/A | 041404/13:13/224&118 |

### Comments:

1. For the 440 BHP engine, the engine coolant out temperatures were less than the 230°F limit because the transmission would shift to converter operation when higher TE limits were attempted.

2. The 500 BHP engine had sufficient torque to establish a higher TE than the 440 BHP without engine coolant overheating. However the engine oil sump exceeded the desired intermittent limit of 250-275F. The limit was increased to 290°F for these tests after consultation with the oil supplier.

## II. DDC EPQ

### A. Cooling System

#### a. Fill Test

The system fill was first done with both blocked open thermostats which were already installed and then with the normally operating stats. In both cases the system filled easily at the pumping flow rate of 2 GPM. The spec is 3 GPM but the shop pump did not flow any faster. In my estimate it could handle 3 GPM about the same.

Fill was through the solid radiator cap. The coolant entered the cross flow radiator and without being obstructed it entered the pump inlet and filled the engine and surge tank from the bottom up. Air venting was both to the surge tank through the engine vents and through the vents leading directly to the cap. The final total capacity was 18.5 gallons and when the engine was started the flow and pump pressure was immediately established without any air locking. The venting during the engine rotation and purging was from the crossover pipe to the surge tank in a very efficient manner, as was the flow in all venting lines. The make up after shut down was almost nil being about 1/2 pint. Overall the system has a good fill capability.

## b. Flow Tests

### 1) 8V71T Standard Water Pump

The flow with the standard 8V71T water pump was actual system flow and was accompanied by pressure measurements at various locations in the cooling system. The flow at max RPM is in fig 2 table and flow VS RPM is in fig 3 and 4. The flow was very good and exceeded the DDC specification. There was a 7 PSI external pressure drop through the radiator and connected piping, which is considered normal. The results are as follows:

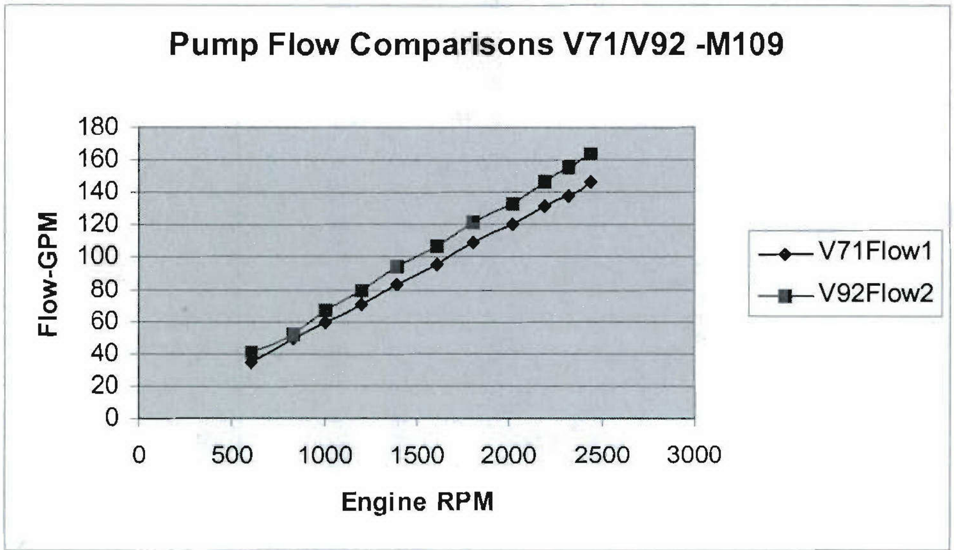
**Fig. 2-Table Of System Pressures At Max Flow, Standard 8V71T Water Pump.**

| System Pressures at max flow and RPM | | |
|---|---|---|
| RPM | 2440 No-Load | |
| FLOW | 147 GPM (138 at 2300 RPM, DDC spec is 126) | |
| Pump Pressure Out | 19.0 psig | |
| Engine out to Rad. Inlet | 9.2 psig | |
| Radiator out | 3.8 psig | |
| Pump in | 2.9 psig | |

### 2) 8V92T Water Pump

Initially TACOM approved of proceeding to provide an 8V92T water pump for test on this engine. So it was furnished after much development effort to adapt and a no-load flow test was run. First the 8V71 pump was run as a baseline, then the 8V92 T pump was installed and tested on the power pack in the same manner at no-load on the test cell floor. There was a 10% - 14% increase in flow at the various RPM's. The results of flow and pressure comparisons are shown below (**Figs 3 and 4** ).

Fig-3 Chart Of 8V71T VS 8V92T Water Pump Flow Comparison In M109A6 Paladin




| Fig-4 Table :Coolant Flow and Pressure Drop Comparisons –M-109A6 Paladin 8V71 T-LHR | | | | | |
|---|---|---|---|---|---|
| Engine RPM-Approx | 8V71T Pump Flow-GPM | 8V92T Pump Flow-GPM | 8V71T Pump Pressure-Psig | 892T Pump Pressure-Psig | % flow difference |
| 2440 NL | 147 | 164.4 | 19.4 | 25.2 | 11.8 |
| 2300 | 138 | 155.3 | 19 | 21.8 | 12.5 |
| 2200 | 131 | 147.1 | 17.7 | 20.2 | 12.3 |
| 2000 | 120.5 | 133.3 | 15.5 | 17.5 | 10.6 |
| 1800 | 108.8 | 121.1 | 13.2 | 14.8 | 11.3 |
| 1600 | 96.2 | 107.3 | 11 | 12.2 | 11.4 |
| 1400 | 82.8 | 94.7 | 8.8 | 10 | 14.4 |
| 1200 | 70.9 | 79.5 | 7.1 | 7.8 | 12.1 |
| 1000 | 59.6 | 66.5 | 5.8 | 5.8 | 11.6 |
| 800 | 49.9 | 52.5 | 4.8 | 4.8 | 5.2 |
| 600 Idle | 34.8 | 40.4 | 3.8 | 3.6 | 1.6 |

It is quite obvious from the data table and the chart that there is a 10 to 14 % coolant flow improvement in the working range when using the 8V92T water pump over the 8V71T. It is believed that this would lead to better cooling due to a better Reynolds number as well as higher mass flow which is particularly needed at low RPM's. It only needs to be tested.

The following is the hardware information needed to make the adaptation of the NAPCO engine 7083-7491, 8V92T water pump to the M109 TACOM engine 7083-7391. See table **(fig.5)**.

**Fig-5 Parts Tabulation of 8V71T vs 8V92T Water Pump Exchange**
**Group and parts comparisons:**

| Name | 7083-7391 M-109 TACOM | Description | | 7083-7491 NAPCO | Description |
|---|---|---|---|---|---|
| **Water Pump Group** | **06K02-0274** | 8V71T Water Pump. | | **06K02-0383** | 8V92T Water Pump. |
| -Water Pump Assy | 5103506 | 8V71T No Bypass | | 23506018 | 8V92T With Bypass |
| --Water Pump Body | 5135455 | Vert. 2.75" Inl.,Vert Outl. | | 8922325 | Vert 3.00"Inl.,angled Outl.* |
| **Oil Cooler Group** | **06G03-0802** | Oil Cooler & connections | | **06G03-1359** | Oil Cooler & Connections |
| -Water Inlet elbow | 5127904 | Long El.Vert.Pmp.Outl. | | 5101409 | Short El.Angled Pmp.Outl. |
| -Hose | 23503674 | 2.38x2.76 Silicon | | 5107607 | 2.75x2.62 Silicon |
| -Gasket | 5124822 | Elbow to Oil Clr. Hsg. | | 5124822 | El to Oil Clr. Hsg. |
| **Cam Damper Group** | **06C02-0263** | Cam Damper, solid | | **06C02-0299** | Cam Damper, Rubber bush |
| -Damper Assy | 5109863 | Cam Damper-solid | | 5101171 | Cam Damper, Rubber bush |

*1. The 23506018 water pump has to be modified to adapt to the 7083-7391 model as follows:

a. Cut the bypass off and weld a cover plate over the hole as the engine by pass is not utilized on this M109 engine model.

b. Provide a 1/8" NPT hole in this cover plate at the top of the impeller chamber.

c. Reduce the diameter of the inlet from 3-1/2" to 3-1/4" by brazing a sleeve to adapt to the vehicle piping, or make a step up adapter pipe in the vehicle. (The latter is the recommended).

2. Due to the angle of the 8V92 pump outlet to the oil cooler, compared to no angle on the present 8V71T pump, provide a 5101409 inlet elbow and 2.75" hose, clamps, and a new gasket to replace the existing pump to oil cooler adapter elbow.

3. Due to interference of the 8V92 pump housing with the cam balancer, the 8V92 rubber bushed vibration damper must be installed to replace the solid 8V71T cam balancer.

4. When the pump is installed, align and adjust any gear backlash needed, then install the cover plate and large snap ring.

All of these tasks were done for this project and the pump and its attaching components were returned to the DDC government storage room near on May 14, 2004 to be held for future testing, should it arise.

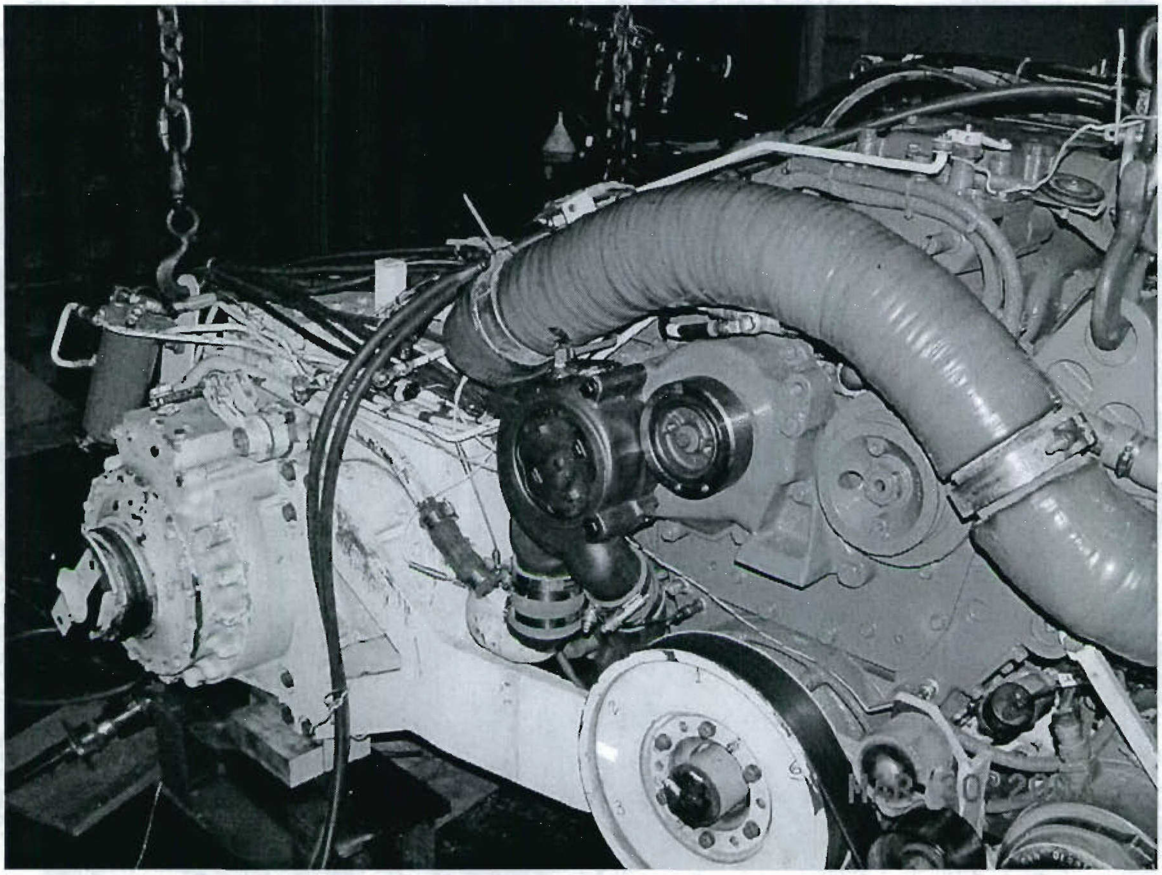


Photo-1 8V92T Coolant Pump And Damper Installed On 8V71T Paladin Engine

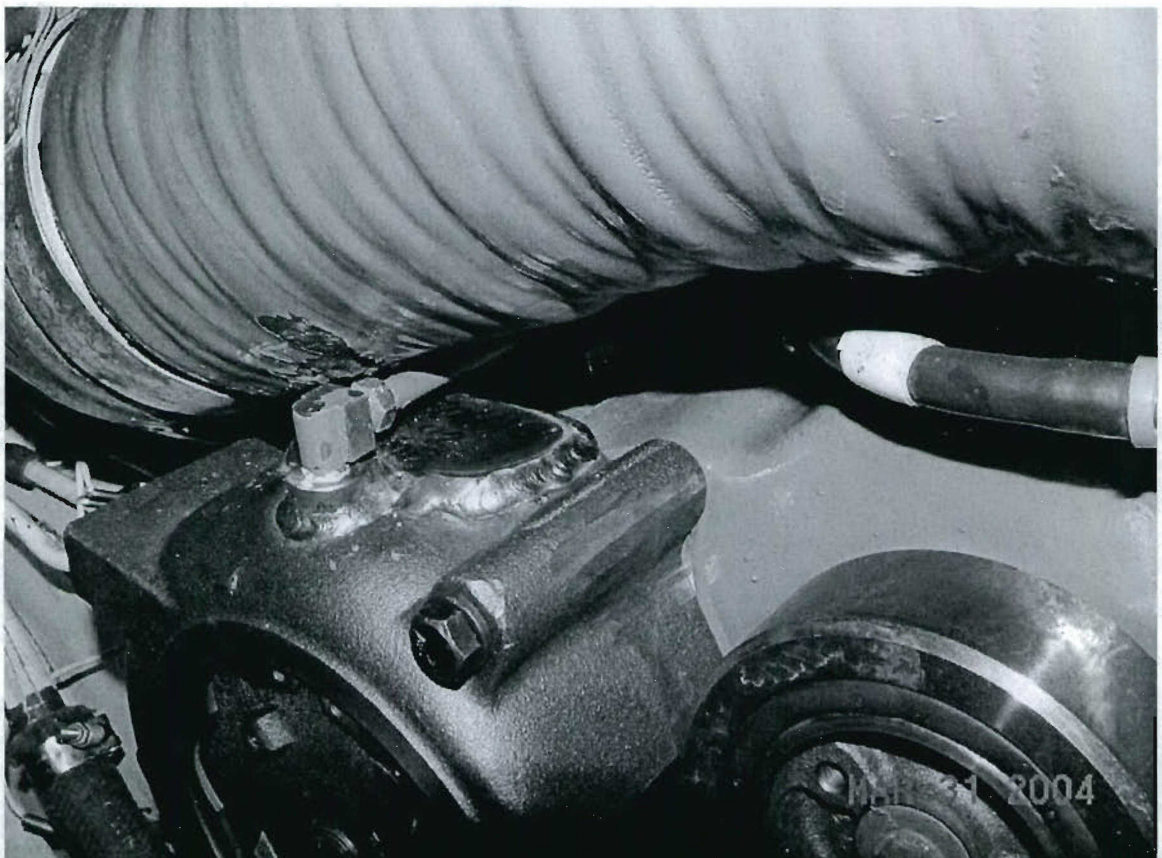



Photo –2 Close Up Of 8V92T Pump Vent And Closeness To Exhaust Crossover.

## c. Drawdown Tests

Two drawdown tests were performed on the system, once with the 8V71T water pump and once with the 8V92T water pump installed. In both cases the system survived very well as coolant was drained until the DDC specified limit of 10% was drained off and small bubbles just began to appear. Thus the 18.5 gallon system had 1.8 to 1.9 gallons removed before air appeared in the fill line. This was accomplished by having a site glass installed in the engine coolant outlet to the radiator and clear tubes in the fill line and all vents.

## d. Deaeration Tests

For both pumps deaeration was accomplished by continuing the drawdown test beyond the drawdown point so that, with more and more coolant loss, the system coolant became thoroughly saturated with air. This is a substitute method for the 0.8 CFM of injected air which used to be the required procedure. With the engine still running at No Load speed coolant was returned to the system by pumping it back in at a point near the pump suction. As coolant was returned the air was continually expelled through the vent lines, first to the surge tank and then from the upper tank vent to the overflow line, which was open to atmosphere. All vent lines functioned well and the original flow was recouped within 5 minutes and the water became solid in flow within 10 -20 minutes. One problem in determining if there is solid flow without air is that the coolant inhibitor becomes slightly foamy and holds the foam a long time making it difficult to visually establish clarity of the coolant.

## e. Cooling Index

The cooling index of the system was determined from TACOM data taken while the entire vehicle was on the dynamometer. The ambient temperature was stepped up in 5°F increments beginning at about 95°F and continued on up to the required limit of 115°F prevailed. The engine was run at full load and the dynamometer absorption torque was increased in steps by lugging down and at the same time lowering the RPM until a specified tractive effort to the vehicle weight ratio is obtained (TE/Wt). This could only be done with coolant temperature stabilization if the transmission remained in lock up.

First, baseline cooling at various TE/Wt and ambient temperatures was run. The TE/Wt was increased until either the engine reached maximum coolant out of 230°F was reached or the transmission shifted into torque converter operation and stability couldn't be maintained.

**Fig. 6- Samplings and Comparisons of Full Load Cooling Test Data at 115°F Ambient**

| BHP/Torque Converter | 440 - TC-360 High RPM | 440-TC-360 Low RPM | 440-TC-396 High RPM | 440-TC 396 Low RPM | 500-TC396 High RPM | 500-TC-396 Low RPM |
|---|---|---|---|---|---|---|
| Engine Speed RPM | 1980 | 1631 | 2121 | 1651 | 1924 | 1610 |
| Ambient Temp. °F | 115 | 115 | 115 | 115 | 115 | 115 |
| TE/Wt Ratio | .307 | .33 | .307 | .34 | .35 | .37 |
| Coolant flow GPM | 104.3 | 86.0 | 117 | 90.6 | 118.0* | 98.8* |
| Engine coolant out temp. °F | 223.3 | 221.3 | 220.4 | 220.4 | 230.1 | 227.3 |
| Radiator Coolant out °F | 210.1 | 207.6 | 208.1 | 207.2 | 217.8 | 214.3 |
| Coolant Δ across Radiator °F | 13.2 | 13.7 | 12.3 | 13.2 | 12.3 | 13.0 |
| Calculated Heat Rejection BTU/MIN | 11,152 | 9543 | 11,657 | 9687 | 11,756 | 10,404 |
| Average Air Temp. To Fan °F | 140.1 | 138.4 | 138.6 | 140.1 | 143.1 | 143.2 |
| Calculated Cooling Index based on Ambient °F | 108.3 | 106.4 | 105.4 | 105.4 | 115.1 | 112.3 |
| Calculated Cooling Index based on Air temp to fan °F | 83.2 | 83 | 81.8 | 80.3 | 87.0 | 84.1 |
| Engine Oil Sump Temp. °F | 266.4 | 260.6 | 265.5 | 260.7 | 285.1 | 280.3 |
| Engine Oil Gallery Temp. °F | 238.3 | 235.1 | 237.4 | 235.0 | 257.1 | 252.6 |
| Coolant to Oil Cooler °F | 210.9 | 208.5 | 209.2 | 208.2 | 219.3 | 216.1 |
| Calculated( Oil Gal.-Clnt.In) Temp °F | 27.4 | 26.6 | 28.2 | 26.8 | 37.8 | 36.5 |
| Calculated Sump-ClntOut Temp °F | 43.1 | 39.2 | 45.2 | 40.3 | 55.0 | 53.0 |
| Transmission Oil Sump °F | 237.1 | 232.1 | 238.2 | 232.6 | 243.9 | 237.6 |
| Transmission Oil ToClr °F | 240.3 | 235.0 | 240.5 | 234.1 | 245.9 | 239.1 |
| Average Air to Rad Core °F | 151.8 | 148.0 | 150.1 | 148.3 | 151.8 | 149.9 |
| Average Air out of Core °F | 181.0 | 181.2 | 177.4 | 180.4 | 184.8 | 184.9 |
| Avg Air Temp.Dif.in/out-Core °F | 29.2 | 33.2 | 27.3 | 32.1 | 33.0 | 35.0 |
| File date/name/time | 12/10/03/-/-/ 13:26 | 12/10/03/- /-/ 14:21 | 02/05/04/ -/- 12:35 | 02/05/04/ -/- 14:30 | 04/14/04/ 118/224/1 2:31 | 04/14/04/ 118/224/ 13:13 |

* These flow values were not part of the data file. They were recorded manually and given as values separately from the data.

## Comments and suggestions on cooling index:

1. The **Cooling Index based on ambient temperature** for the 500 BHP is up higher than the 440 BHP engine as expected by 7–10°F due to the greater heat rejection. The 115°F Air-to-Water (ATW) differential would allow full load operation of the engine in 115°F ambient with the coolant at the limit of 230°F.

2. **Cooling Index based on air temperature to the fan** is considerably less than based on ambient, which is a result of high temperature rise of air to the fan. The 87°F ATW indicates the cooling system and radiator have good cooling capacity if allowed to receive cooler ambient air.

3. The high temperature rise of engine compartment air to the fan inlet (about 28°F rise) is partially a result of **restricted cooling fan air flow** into and out of the engine compartment via the ballistic grills. There are also effects of radiation and convective

heat transfer from the engine and piping. In order to determine how much of a contribution airflow restriction is it is proposed that a test be run with the ballistic louvers removed.

4. The calculated **engine oil sump to coolant out temperature differential,** running 43-45°F for the 440 BHP engine and 53-55°F for the 500 BHP engine, shows an increase of about 10°F in the 500 BHP engine over the 440 BHP engine. This is in spite of increasing the tube bundle size from 36 to 42 tubes. The results are slightly higher than the 7°F increase found from the engine lab dynamometer tests. It is recommended that the 8V92T water pump be tested to see if more coolant flow, especially at low RPM would help the situation.

5. The average cooling fan **air temperature differential across the radiator core** was in the range of 30 - 35°F, which is slightly above the normal range of 25 - 30°F, indicating a need for improved airflow.

### Suggestions:

1. Since a drop in coolant flow had adverse effects, perhaps an increase in coolant flow may improve cooling. This might be especially effective at the lower RPM's, due not only to more mass flow to give a lower $\Delta T$ across the radiator, but more turbulence (Higher Reynolds No.) in the tubes. This and other concepts should be considered in case of future development and testing as follows. It is suggested to install the 8V92T water pump to obtain a higher flow especially at the lower RPM's.

2. Install a pre-cooler on the air intake.

3. Determine a lower calibration injector to achieve the desired performance results with less heat input. Determine this by firstly running at part throttle and lower RPM's to get the torque needed without the excessive fuel input.

4. Test for fan air flow deficiency by running comparison tests with and without the ballistic louvers. This could lead toward a redesign to reduce airflow resistance and thereby improving the system cooling capability.

### Other cooling index tests.

The results of **replacing the leaking exhaust tail pipe and cleaning the radiator** core are shown in fig. 7 and show that there was some improvement.

The results **of installing a coolant mixing device** for a more homogeneous temperature strata at the inlet to the radiator are shown in fig. 7. As it turned out, there was a drop in coolant flow due to the increased restriction and a subsequent rise in operating temperature (Fig.7).

**Fig. 7- Table of Misc. Cooling Index tests and results.1- before and 2-after replacing exhaust and cleaning radiator core at 105°F ambient. 3-Installing Mixer.**

| | Exhuast Leak/ Plugged . Core | New Exhaust/ Rad Cleaned | Mixerinstalled in pipe to Rad. |
|---|---|---|---|
| **Engine Speed RPM** | 2141 | 2115 | 2120 |
| **Ambient Temp. °F** | 105.4 | 105.6 | 105 |
| **TE/Wt Ratio** | 0.33 | 0.33 | 0.33 |
| **Coolant flow GPM** | 130.8 | 128.7 | 125 |
| **Engine coolant out temp. °F** | 227.2 | 221.0 | 224.3 |
| **Radiator Coolant out °F** | 214.7 | 208.6 | 211.0 |
| **ΔT across Radiator °F** | 12.5 | 12.4 | 13.3 |
| **Calculated Heat Rejection BTU/MIN** | 13,244 | 12,927 | 11,312 |
| **Average Air Tem. To Fan °F** | 135.3 | 129.9 | 131.5 |
| **Calculated Cooling Index based on Ambient °F** | 121.8 | 115.4 | 119.3 |
| **Calculated Cooling Index based on Air temp to the fan °F** | 91.9 | 91.1 | 92.8 |
| **Engine Oil Sump Temp. °F** | 281.2 | 276.0 | 279.3 |
| **Engine Oil Gallery Temp. °F** | 255.2 | 249.4 | 252.5 |
| **Coolant to Oil Cooler °F** | 215.8 | 209.9 | 212.8 |
| **Calculated Gal.-Clnt.Inlet Temp. ° F** | 39.4 | 39.5 | 39.7 |
| **Calculated Sump-ClntOut Temp °F** | 54 | 55 | 55 |
| **Transmission Oil Sump °F** | 243.8 | 232.7 | 239.6 |
| **Transmission Oil ToClr °F** | 246.2 | 239.8 | 242.3 |
| **Average Air to Rad Core °F** | 145.4 | 141.4 | 140.2 |
| **Average Air out of Core °F** | 181.2 | 174.6 | 176.9 |
| **File date/name/time** | 03/02/04/205/98/ 12:02 | 04/06/04/219/113 12:03 | 04/16/04/120/226/1 2:00 |

## B. Air Inlet and Exhaust System

The air Inlet is located in the crew compartment and is not directly exposed to dust and changing out the elements is not too difficult. There are some sharp 90 deg. Bends and flex hose that contribute to air inlet restriction, which exceeds DDC specs in both the 440 and the 500 BHP engine case.

The wire-wound flex hose is also counter to DDC recommendations, as the wire tends to wear through in time. It also is a contributor to air inlet restriction. See fig. 8 for air inlet restriction comparisons.

The exhaust system consists of a large single piece which connects the 5" round engine turbo outlet to the 2"x 9" oval hull mounted tail pipe. No flexibility was observed. The thin stainless steel adapter is subject to vibration, cracking and leakage as was observed in this vehicle. A large piece of the sheet metal had broken away and poured exhaust and soot into the engine compartment, creating problems with the radiator core and cooling. The exhaust system was replaced by a new one before the final testing of the 500 BHP engine. Like the air inlet restriction, the exhaust restriction is up slightly with the 500 BHP engine compared to the 440 BHP engine. Also, the backpressure of the 440 BHP engine is already in excess of DDC recommendations.

**Fig.8: Air Inlet and Exhaust System Restriction Comparisons.**

| Full Load Conditions during measurement | Air Inlet Restriction | DDC limit with new air cleaner element | Exhaust Back pressure | DDC Limit at full load 2300 rpm |
|---|---|---|---|---|
| 440 HP/2120 RPM | 17.7" H2O | 12" H2O | 3.68" Hg | 3" Hg |
| 500 HP/2120 RPM | 18.5" H2O | 12" H2O | 3.74" Hg | 3" Hg |
| 500 HP/2325 RPM | 20.86" H20 | 12" H2O | 4.00" Hg | 3" Hg |

## C. Fuel and Lube System:

The fuel tanks are of odd diverse shapes to fit in the voids of the engine compartment. There is a transfer pump at the tanks to take suction and deliver to the engine so the pressure at engine fuel pump inlet is expected to be on the positive side. An attempt to measure it during the FLCT tests showed positive pressure, but this was with a remote pump. A similar test still needs to be done with the power pack installed in the vehicle using the onboard pumps to verify inlet restriction or pressure. This can be done at a later date when the vehicle is available. The fuel filters are remote mounted and easily accessed through the engine compartment hatch.

The lube oil filters are remote mounted and easily accessed through the engine compartment hatch. An attempt to measure pressure drop through the remote filter system was difficult due to flow meters and adaptation hardware. This and fuel inlet pressure should be measured in the vehicle under normally installed conditions.

**Roger Hewlett**
**09 July 2004**

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# APPENDIX E

*Tractive Effort Model*

ROAD WHEEL OR SPROCKET TRACTIVE EFFORT MODEL (English Units)

The vehicle road wheel or sprocket tractive effort $T_{ew}$ model is one component of fifteen sub-models of the total propulsion system and vehicle dynamics work by Mr. Milad H. Mekari from TACOM mobility propulsion research, and is specified in the English Customary System of Units as follows:

$$T_{ew} = \frac{1}{R_{wd}}(5252.11\frac{N_e}{n_1})i_{12} * \eta_{mdl}$$

Where:

$T_{ew}$ = Road Wheel Tractive Effort or the Sprocket Tractive Effort [Lb ] force

$R_{wd}$ = Dynamic radius of the road wheel or dynamic radius of the sprocket at vehicle track [FT]

Ne = Engine brake horsepower [BHP] in English units

$n_1$ = Engine RPM at the Ne value [1 / MIN]

$\eta_{mDL}$ = Mechanical efficiency of the total propulsion system driveline, from the engine flywheel to vehicle axles; or from the engine flywheel to the vehicle sprocket. Mechanical efficiency could be in the range of 75% to 98%

$i_{1,2}$ = Total driveline gear/speed ratio from the engine flywheel to road wheel or from the engine flywheel to the propulsion system sprocket.

It is noted that 500 HP (English) = 506.945 HP (Metric)

Also, 1 HP (English) = 550 Ft – Lb/Sec = 33,000 Ft – Lb./ Min

And 1 HP (Metric) = 75 Kg – M/Sec = 735.499 WATTS ≅ 735.5 w.

Also 1 HP (Metric) = 542.464 Ft – Lb./Sec

And 1 HP (English) = 1.0138924 HP (Metric) = 745.6999 WATTS ≅ 745.7 w.
1 m =3.2808 ft
$1kg_{force}$ = 2.2046 lbs

ROAD WHEEL OR SPROCKET TRACTIVE EFFORT MODEL (Metric Units)

The same tractive effort model is written in the Metric Customary System of Units as follows:

$$T_{ew} = \frac{1}{R_{wd}}\left(716.2\frac{N_e}{n_1}\right)\eta_{mDL} i_{12}$$

Where:

$T_{ew}$ = Road Wheel Tractive Effort or the Sprocket Tractive Effort [Kg ] force

$R_{wd}$ = Dynamic radius of the road wheel or dynamic radius of the sprocket at vehicle track [m]

Ne = Engine brake horsepower [BHP] at n RPM

$n_1$ = Engine RPM at the Ne [1 / MIN]

$\eta_{mDL}$ = Mechanical efficiency of the total propulsion system driveline, from the engine flywheel to vehicle axles; or from the engine flywheel to the propulsion system sprocket. Mechanical efficiency could be in the range of 75% to 98%.

$i_{1,2}$ = Total driveline gear/speed ratio from the engine flywheel to road wheel or from the engine flywheel to the propulsion system sprocket.

Note that the $T_{ew}$ model is made to be used to compute the propulsion system parameters at various engine loads and rotational speeds. Also, the $T_{ew}$ model is intended for use as a propulsion system design tool, in vehicle acquisition and vehicle source selection evaluation boards (SSEBs), and could be coded and embedded into the vehicle diagnostic system for data collection on various vehicle parameters during vehicle operations.

## THE VEHICLE TRACTIVE EFFORT MODEL (TEW)

Notes:

1. Use Mr. M. Mekari tractive effort ($T_{ew}$) wheel/sprocket model as a propulsion system design tool, or if you want to check on the field conditions of the propulsion system versus its design parameters.
2. An example of the model usage is to calculate the ($T_{ew}$) to (GVW) ratio, and to enter the results into the Top Tank Temperature (TTT) model.
3. The ($T_{ew}$) model can be used universally for wheeled, tracked, and hybrid vehicles.
4. The ($T_{ew}$) model is written in both English and metric systems of units. The full details are in the attached pages.
5. When the ($T_{ew}$) model is coded/programmed, it can be efficiently used to calculate the tractive effort (or any other parameters of the ($T_{ew}$) model) for various road loads and various vehicle speeds.
6. Enter into the ($T_{ew}$) model engineering design data from the manufacturers of engine, transmission, gear box, road wheel or sprocket.
7. All the parameters that should be entered into the ($T_{ew}$) model to arrive at the tractive efforts at the sprocket or road wheel are listed in the attached pages.
8. The ($T_{ew}$) model has been validated on various automotive propulsion systems, and on paladin M109A6 propulsion system of DD8V71T and TA engines.
9. You can use the $T_{ew}$ model to check on a fielded vehicle "HP" from combined tests and design parameters data of the propulsion system as follows:

$$Ne = \frac{T_{ew} \times R_{WD} \times n_1}{716.2 \times \eta_{mDL} \times i_{12}}$$

Ne = Engine $[HP]_{metric}$

$T_{ew}$ = Sprocket tractive effort [Kg] force

$R_{wd}$ = Dynamic radius of the road wheel or dynamic radius of the sprocket at vehicle track [m]

716.2 = Ct. --- $[\frac{kgm}{\min}]$

$n_1$ = Engine [RPM]

$\eta_{mDL}$ = Driveline mechanical efficiency (0.75 to 0.98)

$i_{12}$ = Total driveline components gear ratio = $i_{c_1} * i_{c_2} * \text{-----} = \frac{n_1}{n_2}$

$n_1$ is the engine RPM, and $n_2$ is the road wheel or sprocket RPM

For user convenience, each parameter of the ($T_{ew}$) model is written in English and in Metric systems of units as follows:

Propulsion System models and parameters in English system of units:

$$T_{cw} * R_{wd} * n_1 = 5252.11 * N_e * \eta_{mdl} * i_{12}$$

$$T_{ew} = \frac{1}{R_{wd}}\left(5252.11\frac{N_e}{n_1}\right)\eta_{mDL} i_{1,2}$$

$$N_e = \frac{T_{ew} * R_{wd} * n_1}{5252.11 * \eta_{mDL} * i_{1,2}}$$

$$\eta_{mDL} = \frac{T_{ew} * R_{wd} * n_1}{5252.11 * N_e * i_{1,2}}$$

$$i_{1,2} = \frac{T_{ew} * R_{wd} * n_1}{5252.11 * N_e * \eta_{mDL}}$$

$$R_{wd} = \frac{5252.11 * N_e * \eta_{mDL} * i_{1,2}}{T_{ew} * n_1}$$

$$n_1 = \frac{5252.11 * N_e * \eta_{mDL} * i_{1,2}}{T_{ew} * R_{wd}}$$

English Units to be used in the computation of the above listed models are:

| | |
|---|---|
| $T_{ew}$ | $[lb]_{weight}$ |
| $R_{wd}$ | [ft] |
| $n_1$ | $[\frac{1}{\min}]$ |
| 5252.11 | $\frac{lb-ft}{\min}$ |
| $N_e$ | $[HP]_{english}$ |

Propulsion System models and parameters in Metric system of units:

$$T_{ew} * R_{wd} * n_1 = 716.2 * N_e * i_{12} * \eta_{mdl}$$

$$T_{ew} = \frac{1}{R_{wd}}(716.2 * \frac{N_e}{n_1}) * i_{12} * \eta_{md}$$

$$N_e = \frac{T_{ew} * R_{wd} * n_1}{716.2 * i_{12} * \eta_{mdl}}$$

$$\eta_{mdl} = \frac{T_{ew} * R_{wd} * n_1}{716.2 * N_e * i_{12}}$$

$$i_{12} = \frac{T_{ew} * R_{wd} * n_1}{716.2 * N_e * \eta_{mdl}}$$

$$R_{wd} = \frac{716.2 * N_e * i_{12} * \eta_{mdl}}{T_{ew} * n_1}$$

$$n_1 = \frac{716.2 * N_e * i_{12} * \eta_{mdl}}{T_{ew} * R_{wd}}$$

Metric Units to be used in the computation of the above listed models are:

| | |
|---|---|
| $T_{ew}$ | $[kg]_{weight}$ |
| $R_{wd}$ | $[m]$ |
| $n_1$ | $[\frac{1}{\min}]$ |
| 716.2 | $[\frac{kgm}{\min}]$ |
| $N_e$ | $[hp]_{metric}$ |

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